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HIGH ALTITUDE VEHICULAR EMISSION CONTROL PROGRAM

VOLUME II. EXPERIMENTAL CHARACTERIZATION OF IDLE INSPECTION, EXHAUST CONTROL RETROFIT AND MANDATORY ENGINE MAINTENANCE

AUTOMOTIVE TESTING LABORATORIES,
INCORPORATED

PREPARED FOR
ENVIRONMENTAL PROTECTION AGENCY

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A sample of 300 of the 1964 through 1973 model-year vehicles was utilized to investigate the effectiveness and feasibility of several exhaust emission control strategies as might be applied in the Colorado environment. Four strategies were evaluated; idle emissions inspection in the private sector, exhaust control retrofit, modified engine tuning specifications and mandatory engine maintenance. Each of the strategies is discussed for effectiveness in reducing exhaust hydrocarbon, carbon monoxide, and oxides of nitrogen emissions.

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PREFACE

This report is the second of a seven volume report prepared for the State of Colorado, Department of Health and the Environmental Protection Agency, Region VIII. The title of each respective volume is as follows:

Volume I	Executive Summary
Volume II	Experimental Characterization of Idle Inspection, Exhaust Control Retrofit and Mandatory Engine Maintenance
Volume III	Impact of Altitude on Vehicular Exhaust Emissions
Volume IV	Analysis of Experimental Results
Volume V	Development of Techniques, Criteria, and Standards to Implement a Vehicle Inspection, Maintenance and Modification Program
Volume VI	The Data Base
Volume VII	Experimental Characterization of Vehicular Emission and Engine Deterioration

These reports describe the design, conduct, findings and conclusions of study programs initiated in compliance with the requirements of the Colorado Department of Health and the Environmental Protection Agency. Volume II describes the design of an experimental program to investigate several elements of emission control; idle emission inspection, exhaust control retrofit, modified engine tuning specifications and mandatory engine maintenance.

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Finally, a sincere thanks for a job well done is extended to the staff and personnel of Automotive Testing Laboratories, Inc.

SUMMARY

A sample of 300 of the 1964 through 1973 model-year vehicles was utilized to investigate the effectiveness and feasibility of several exhaust emission control strategies as might be applied in the Colorado environment. Four strategies were evaluated; idle emissions inspection in the private sector, exhaust control retrofit, modified engine tuning specifications and mandatory engine maintenance. Each of the strategies proved to be effective in reducing exhaust hydrocarbon and carbon monoxide emissions. Increased oxides of nitrogen emissions were measured with respect to certain of the strategies.

Summarily, it was shown that hydrocarbon and carbon monoxide emissions can be decreased 11% and 7% respectively by idle emissions inspection and maintenance at 40% rejection of vehicles. A slight decrease in oxides of nitrogen emissions and a slight increase in fuel economy were also measured.

The more costly exhaust control retrofits were the most effective in HC and CO reduction with catalytic systems showing reductions of 75% and 85% respectively. Of the less costly systems investigated, the air bleed and float bowl pressure regulation systems show good HC and CO reduction at 20% and 35% respectively with an increase in NO_x emissions of about 25%. On the average the high altitude modification kits showed little change in HC emissions, a reduction in CO emissions of about 15% and an increase in NO_x emissions of about 30%. The Air Bleed/EGR systems appear to represent the best compromise in emissions control with a range in reduction of 20% HC, 30% CO and 25% NO_x.

Certain combinations of modified engine tuning adjustments showed good potential for HC and CO reduction of about 10% and 20% respectively although NO_x emissions increased about 20% as a result of this application.

Mandatory engine maintenance also showed good potential for HC and CO reduction with HC reduction measured at 20% and CO reduction measured at 10%. Application of mandatory maintenance resulted also in decreased NO_x emissions of about 10%. Mandatory maintenance was shown to be one of the least cost effective of all strategies investigated, however.

CONCLUSIONS

1. Each of the strategies investigated was found to be effective in reducing HC and CO emissions.

   1.1 The range of reduction for HC is from a low of about 1% for the high altitude kits to a high of about 75% for catalytic retrofit.

   1.2 The range of CO reduction is from a low of about 3% for idle emissions inspection at 20% rejection to a high of about 85% for catalytic retrofit.

   1.3 The range of NO_x reduction is from a low of about -30% for the high altitude kits to a high of about 45% for VSAD/Air Bleed retrofit.

2. The range of cost effectiveness (CE) is wide.

   2.1 CE for HC ranges from a low of 5 milligrams/mile/dollar (mmd) for the high altitude kits and LPG conversion to a high of about 100 mmd for idle emissions inspection at 30 to 60% rejection and certain combinations of modified engine tuning adjustments.

   2.2 CE for CO ranges from a low of about 75 mmd for LPG conversion to a high of about 4000 mmd for certain combinations of modified engine tuning adjustments.

   2.3 CE for NO_x ranges from a low of -75 mmd for the high altitude kits to a high of about 50 mmd for VSAD/Air Bleed retrofits.

3. With respect to idle emissions inspection and maintenance:

   3.1 The effectiveness curve for HC rose sharply from 0 to 30% rejection and continued to rise at a reduced rate to 60% rejection. HC reduction at 30% rejection is about 10%. At 60% rejection HC reduction is about 13%. CE for HC rose sharply from 0 to 30% rejection. The CE curve is relatively flat from 30 to 60% rejection at a level of about 100 mmd.

   3.2 The effectiveness curve for CO rose sharply from 0% to 30% rejection and continued to rise at a reduced rate through 60% rejection. CO reduction at 30% rejection is about 5%. At 60% rejection CO reduction is about 9%. CE for CO rose sharply from 0% to 30% rejection and continued to rise at a reduced rate through 60% rejection. CE at 30% rejection is about 750 mmd. At 60% rejection CE is about 1000 mmd.

   3.3 The effectiveness curve for NO_x rises gradually from 0 to 60% rejection. At 60% rejection NO_x reduction is about 2%. The CE curve rises sharply from 0 to 20% rejection and continues to rise at a reduced rate through 60% rejection. CE at 30% rejection is about 3 mmd. At 60% rejection CE is about 5 mmd.

   3.4 The garages (licensed safety inspection stations) selected to perform idle emissions inspection represent a cross-section of the automobile repair industry.

   3.5 Training provided to station personnel was adequate with respect to task objectives. However, more extensive training is required with respect to an overall emissions control program.

   3.6 The idle emissions inspection, adjustment and repair procedures provided to garages was adequate. Application of these procedures resulted in substantial emissions reductions and reasonable cost effectiveness ratios. However, several problems were experienced with station personnel with respect to data transmittal and attention to inspection pass/fail limits.

3.7 Actual inspection failure rates were higher than design failure rates. The difference is attributed primarily to the performance of one station which failed all vehicles tested. One other station appears to be borderline in this respect.

3.8 Inspection charges range from an average low of $1.50 per inspection at one station to an average high of $6.00 per inspection at another station. The overall average inspection charge is $4.05 which is consistent with laboratory estimated inspection costs.

3.9 The average station cost per failed vehicle ranges from a low of $2.53 to a high of $14.25. The overall average cost per failed vehicle is $10.57.

3.10 The average station repair cost per vehicle for all vehicles ranges from a low of $0.76 to $12.26. The overall average cost per vehicle for all vehicles is $6.14.

3.11 The average combined station cost (inspection and repair) per failed vehicle ranges from a low of $4.76 to a high of $14.76 with an average cost per vehicle of $10.18.

3.12 Average overcharge per failed vehicle is estimated to range from 8 to 22% as determined from direct charges. Average overcharge per failed vehicle is estimated to be as high as 38% if direct repair charges and estimated repair charges to repair problem vehicles are combined. In terms of costs average overcharge per station is from $0.85 to $2.31 per failed vehicle or as high as $4.66 per failed vehicle.

3.13 Correlation coefficients developed between laboratory instrumentation and garage instrumentation are wide in range. Average station correlation coefficients range from a low of 0.43 to a high of 0.83 for HC emissions at curb idle. At 2500 engine rpm the correlation coefficients range from 0.26 to 0.84. For CO at curb idle the range of correlation coefficients is from 0.48 to 0.89. At 2500 engine rpm the range is from 0.26 to 0.89. In this respect the performance of two of the stations (20% of the sample) is unacceptable.

4. With respect to exhaust control retrofit:

4.1 For HC and CO reduction the catalytic system was the most effective with reductions of 75% and 85% respectively. The catalytic system was followed by LPG conversion with 40% and 55% reduction for HC and CO respectively. Catalytic system CE was about 25 mmd for HC and 450 mmd for CO. The CE ratio for LPG conversion was about 5 mmd for HC and 75 mmd for CO.

4.2 Of the remaining retrofits, EGR/Air Bleed combined, Air Bleed alone and Float Bowl Pressure Regulation (FBPR) systems are the most effective HC and CO reducing retrofits with a range from about 17% to 20% HC reduction and 20% to nearly 50% CO reduction.

4.3 For NO_x reduction the VSAD/Air Bleed, VSAD/EGR, EGR/Air Bleed and EGR retrofit are the more effective systems with a range from about 25% to 45% NO_x reduction.

4.4 The change in fuel economy for the various retrofits ranges from an improvement of about 21% for LPG conversion to a deterioration of about 8% for EGR only and VSAD/Air Bleed systems. Of the less costly and elaborate systems fuel economy improved about 2.5% for EGR/Air Bleed and FBPR systems.

4.5 CE for HC ranges from a low of about 5 mmd for EGR and high altitude kit retrofit to a high of about 50 to 60 mmd for EGR/Air Bleed and VSAD/Air Bleed respectively.

4.6 CE for CO ranges from a low of about 75 mmd for LPG conversion to a high of about 1150 mmd for Air Bleed and FBPR systems.

4.7 CE for NO_x ranges from a low of -75 mmd for the high altitude kits to a high of about 50 mmd for VSAD/Air Bleed retrofit.

4.8 Retrofit kits are relatively easy to install except LPG systems and catalytic systems where air pumps are not currently installed. Intrinsic problems are associated with high altitude kit installation performed under typical garage-type conditions.

4.9 The application of retrofit is broad with respect to the add-on systems and the high altitude modification kits. Nearly 100% of the light-duty vehicle population can be retrofitted with one or more systems. High altitude kits supplied by Chrysler Corporation are limited to certain of the carburetor models. Other models are recommended for retrofit as a complete carburetor replacement only.

4.10 Labor and parts costs as applied to the high altitude kits is reasonable with a range from about \$3.90 to \$13.64 per vehicle. With respect to the add-on systems the range is from about \$20 for Air Bleed systems to about \$650 for LPG systems installed. Labor and parts costs for high altitude kit installations are expected to be higher if installed under more exacting conditions.

5. With respect to modified tuning specifications:

5.1 The greatest HC reductions are obtained from modified adjustment combinations of A/F ratio-idle rpm and A/F ratio-choke, both of which are on the order of 15%. Individually, the greatest HC reduction is obtained from the experimental A/F ratio setting where HC reduction is about 10%.

5.2 The greatest CO reductions are derived from modified adjustment combinations of A/F ratio-ignition timing, A/F ratio-idle rpm and A/F ratio-choke which are on the order of 25 to 30%. Individually, the greatest CO reduction is obtained from the experimental A/F ratio setting, where reduction is about 25%.

5.3 Each of the adjustments individually and in combination result in NO_x increases on the order of 20 to 35%.

5.4 Modified tuning adjustments are relatively easy to perform. However, idle rpm adjustments to the experimental value pose problems relating to safety.

5.5 Adjustments can be applied to virtually all light-duty vehicles.

5.6 Adjustment cost for any two of the parameters investigated is estimated to be about \$5.00 per vehicle.

5.7 Low costs and high effectiveness combine to make certain combinations of modified tuning specifications by far the most CO cost effective of the strategies investigated. The most HC cost effective strategy is shared equally by certain of the combined modified tuning specifications and idle inspection and maintenance at the higher rejection rates.

6. With respect to mandatory engine maintenance:

6.1 Mandatory engine maintenance is effective in reducing HC, CO and NO_x emissions. HC reduction is in the order of 20%, CO reduction is about 10% and NO_x reduction is about 8%. An overall fuel economy improvement of about 1% was obtained.

6.2 Cost effectiveness ranking is low primarily because of associated high costs for maintenance. CE for HC was about 30 mmd as opposed to CE for HC of about 100 mmd for idle inspection at 30% and higher rejection rates and modified tuning specifications. CE for CO was about 200 mmd as opposed to a CE for CO of about 4000 mmd for modified tuning speciflations.

6.3 Costs are estimated to average from a low of about $33.00 per vehicle to a high of about $60.00 per vehicle.

6.4 Problems relating to parts installation and engine adjustments are not expected to be unusual.

6.5 Application to light duty vehicles is 100%.

2. RECOMMENDATIONS

1. Since idle emissions inspection and maintenance was found to be an effective and cost effective strategy to reduce exhaust hydrocarbon and carbon monoxide emissions without an accompanying increase in oxides of nitrogen emissions, it is recommended that idle emissions inspection of light-duty vehicles be implemented in the State of Colorado.

   1.1 Because of the various problems which developed through utilization of licensed safety inspection stations to perform idle emissions inspection, it is not recommended that inspection be performed in the existing network of stations. A state owned, state operated network or a privately operated, state enfranchised inspection network exist as alternative inspection strategies. It is recommended that these alternatives be considered.

   1.2 Since the experience gained as a result of the pilot emissions inspection and maintenance program indicates that overall implementation of this strategy will be a sizeable task, it is recommended that a program be developed whereby statewide inspection will ultimately be realized through application of several phases of implementation.

   1.3 Since the idle emissions inspection adjustment and repair procedures utilized in the program were shown to be both effective and cost effective with regard to emissions reduction, it is recommended that these procedures be adapted to suit the specific inspection program ultimately selected.

   1.4 As a result of apparent problems relating to garage-type emissions inspection instrumentation, it is recommended that a thorough evaluation of emissions analytical instrumentation be performed to serve as a basis upon which analytical instrumentation can be selected.

2. Since certain of the California approved exhaust control retrofit devices were found to be both effective and cost effective in reducing exhaust hydrocarbon, carbon monoxide and oxides of nitrogen emissions, it is recommended that a program of mandatory retrofit device installation be implemented.

   2.1 For economic and other reasons it is recommended that light-duty vehicles be defined as comprising three categories of vehicles; fleet vehicles (10 or more vehicles under common ownership), pre-controlled vehicles (1967 and older model-year vehicles) and controlled vehicles (1968 through 1972 model-year vehicles).

      2.1.1 It is recommended that emissions standards of retrofit performance be established for application to fleet vehicles. It is further recommended that emissions standards established for fleet vehicles be related to emissions reductions shown to be feasible by catalytic converter and LP gas conversion tests.

      2.1.2 It is recommended that standards of retrofit performance be established for application to pre-controlled vehicles. It is further recommended that emissions standards established for pre-controlled vehicles be related to emissions reductions shown to be feasible by EGR/Air Bleed retrofit system tests.

      2.1.3 It is recommended that standards of retrofit performance be established for application to controlled vehicles. It is further recommended that emissions standards established for controlled vehicles be related to emissions reductions shown to be feasible by EGR/Air Bleed retrofit system tests.

3. Because of intrinsic vehicle operational problems resulting from installation of the altitude kits under typical garage-type conditions, application of the strategy is not recommended.

4. Certain modified engine adjustments have been shown to be both effective and cost effective in reducing exhaust hydrocarbon and carbon monoxide emissions although the modified adjustments caused an increase in emissions of nitrogen oxides. Consistent with vehicle warranty constraints, an effective program of hydrocarbon and carbon monoxide emissions reduction could be implemented.

5. Although engine maintenance was shown to be an effective exhaust hydrocarbon, carbon monoxide and nitrogen oxides reducing strategy, emissions reductions achieved were not substantially different from those obtained from idle emissions inspection and maintenance. Therefore, a program of mandatory engine maintenance only is not recommended because of its relatively poor cost effectiveness. It is recommended, however, that voluntary engine maintenance be encouraged.

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3. INTRODUCTION

The State of Colorado faces a unique situation with respect to its air pollution problems. With regards to the severity of pollutant levels, the populated area east of the Front Range was given a Priority I designation by the U.S. Environmental Protection Agency. Priority I was assigned to those areas with the most acute air pollution problems. In this respect, motor vehicles are known to play a major role.

Colorado, situated in the Rocky Mountain region, has a topography which ranges from a low of 3,000 feet in elevation to a high of over 14,000 feet. In this regard, problems associated with transportation caused air pollution are compounded by the fact that emission levels are adversely affected by the higher altitudes of the state.

As indicated in the state's air pollution control plan[1], mobile air pollutant sources account for the major part of the state's air pollution. The plan, submitted in compliance with the requirements of the Environmental Protection Agency (EPA), reports that mobile air pollutant sources in the Metropolitan Denver Air Quality Control Region account for roughly 90 percent of the carbon monoxide emissions and 60 percent of both hydrocarbon emissions and the resultant photochemical oxidants formed by atmospheric reaction of hydrocarbons and nitrogen oxides.

In order to deal with air pollution problems caused by mobile sources, the Colorado Legislature, in June of 1973, passed Senate Bill 393 (S.B. 393). The act provided for the establishment of a motor vehicle emissions control program in the State of Colorado. More specifically, it directed the departments of health and revenue to complete certain testing programs and studies and make joint recommendations to the governor and general assembly.

As outlined in S.B. 393, the departments of health and revenue were required to develop pilot and testing programs on a representative sample of motor vehicles. Various emission control alternatives were designated for investigation. These were to include emission inspection and maintenance, air pollution control tune-up, and certain vehicle modification alternatives. Based on the results of pilot programs, the Colorado Air Pollution Control Commission was charged with the responsibility of developing recommendations for implementing control programs. Such recommendations were to include information on the costs and air pollution control effectiveness of control measures. The commission was further charged with the responsibility of recommending legislative and regulatory measures necessary to implement an effective program.

Recognizing the significance of the state's emission control program, the EPA, through its regional office, elected to supplement the state's program. With the supplemental funding provided by the EPA, an overall program was subsequently established to investigate the several emission control strategies under consideration. Services of independent contractors were sought, proposals and bids were accepted and contracts were let.

Several contractors were selected. Each was charged with specific responsibilities relative to the overall program. Olson Laboratories, Inc., which had completed an emission control and inspection program for the state in 1972, contracted to provide consulting services with respect to the development of techniques, criteria, and standards to implement a vehicle inspection, maintenance and modification program. The Olson contract was also to include an assessment of the legal changes required to permit a vehicle modification program and to evaluate public attitudes with respect to proposed emission control programs. Automotive Testing Laboratories, Inc. (ATL) was selected by the state to provide testing and other consulting services to experimentally investigate and characterize the various emission control alternatives outlined in S.B. 393. TRW Inc., by way of an agreement with EPA, Region VIII, contracted to do the analysis, interpretation and evaluation of data developed in the ATL study. The EPA also provided additional support to the program by funding a portion of the ATL study in an area of particular interest to the EPA. The overall program was thereby established.

This report, Volume II, is one of seven volumes which have been prepared in response to S.B. 393. It describes the design, conduct, findings, and conclusions of the program designed to evaluate idle emission inspection, exhaust emission control retrofit, modified tuning specifications and mandatory engine maintenance.

Because of the complexity of the overall program, the technical discussion, which follows, is presented in three parts.

Part I describes in general the program objectives, design and methodology.

Part II describes in more detail the methodology applied with respect to each of the control strategies.

Part III describes specific problem areas which were encountered with respect to several of the strategies investigated. Summary cost data are also presented.

The main body of the report is concluded with a presentation of effectiveness and cost data.

Appendices are provided and are presented in the order in which they are mentioned in the text. Appendices include flow charts which serve to clarify certain aspects of the study, data forms used to accumulate and process data, computerized programs for data audit, standard and special testing programs and tabular test results.

4. TECHNICAL DISCUSSION - PART I

4.1 PROGRAM OBJECTIVES

Primary objectives of the study were to characterize the various elements of:

Idle emissions inspection

Exhaust control retrofit

Modified tuning specifications

Mandatory engine maintenance

A secondary objective was to select, prepare, and test a sample of vehicles for determination of emissions degredation. Details and results of this determination are to be presented in Volume VII, Experimental Characterization of Vehicular Emissions and Engine Deterioration, to be completed in June, 1974.

4.2 PROGRAM DESIGN

To support both primary and secondary objectives of the study the following tasks were to be considered:

A representative sample of vehicles was to be procured to establish effectiveness and cost data to be utilized to evaluate idle emissions inspection in the private sector. This sample was also to be employed to evaluate the overall feasibility and practicality of such a plan.

An active sample of state licensed safety inspection stations was to be selected to perform idle emissions inspection and maintenance functions. Subordinate tasks included the training of vehicle inspection and repair personnel to perform these functions and establishment of idle emissions inspection failure limits.

Generic exhaust control retrofits were to be selected and evaluated and effectiveness and cost data were to be established. Selection of vehicle sub-samples was required.

High altitude retrofit (modification) packages were to be procured and evaluated. Effectiveness and cost data were to be established and the feasibility and practicality of retrofit was to be investigated.

A quantitative measure of the affect of varied engine tuning specifications was required. A prerequisite to the evaluation was selection of a vehicle sub-sample.

A measure of the effectiveness and costs of mandatory engine maintenance was required. To perform this task a sub-sample of vehicles was required.

A representative sample of vehicles was to be initially maintained and tested. Certain of the emission related parts were to be identified with coded markings and adjustments were to be sealed for six month testing recall to determine emissions degradation and the extent of tampering.

The following is a discussion of general criteria and specifications of the study.

Much of Colorado's air pollution is concentrated in the Denver Air Quality Control Region (AQCR). Light-duty vehicles, ie, passenger cars and light trucks, comprise the majority of vehicles in operation. The general test area was dictated by these factors.

The east-central segment of the Denver AQCR was selected as the test site. The area was selected for the following reasons:

It provided an abundance of light-duty vehicles from which a sample could be procured.

It provided an adequate representation and quantity of vehicle safety inspection/repair facilities.

It was in close proximity to ATL personnel and laboratory facilities.

Examination of Colorado registration data indicated that the 1955-1973 model-year segment* represented about 98 percent of the population. However, it did not appear to be practical to investigate the older vehicles. The cut-off level was established at 90 percent which excluded 1963 and older model year vehicles. This segment was culled principally because of the relatively small number registered, high cost anticipated for emissions reduction, and the relatively low monetary vehicle value. To meet these criteria a sample of 300 of the 1964 through 1973 model-year vehicles was subsequently selected.

To evaluate idle emissions inspection a sample of 10 state licensed safety inspection stations was selected. To assure overall uniformity and standardization of procedures, training and instrumentation were provided.

Assuming a loose definition of the term, numerous exhaust control retrofits are marketed. To minimize the potential nuisance of rendering judgement with respect to retrofits offered as candidates, only proven or accredited retrofits were judged to be acceptable. These were primarily confined to California accredited and gaseous fuel systems.

A second category of exhaust control retrofits was scheduled for evaluation. This segment, sponsored and funded by the EPA, was to be comprised of hardware specified for application at altitude, commonly referred to as "high altitude kits". Assistance in this regard was provided by domestic car

*Examined with respect to a precedent established in the State of California.

manufacturers. Kits for foreign made vehicles were not evaluated.

To quantitatively define the affects of certain modified tuning specifications (variable engine adjustments), an experimental adjustment procedure was required. The procedure, designed by TRW, Inc., took into account major emissions related engine adjustment parameters. A vehicle sub-sample to represent the more popular engine/component combinations was required.

In the initial stages of program design, it became apparent that a large segment of the vehicle sample would be exposed to maintenance. These vehicles, destined for utilization in the various vehicle sub-samples, were selected to comprise a sample to evaluate mandatory engine maintenance. Qualification of the sub-sample was to be accomplished by way of a carefully designed test and evaluation procedure.

Finally, implementation of design criteria discussed above would produce a substantial quantity of vehicles which would qualify as candidates to establish emissions degredation factors. In this respect a well designed testing sequence was also required.

In addition to the criteria discussed, standardized testing and evaluation procedures were required to evaluate the various strategies designated for investigation. The 1975 EPA exhaust emissions testing procedure was selected as the basis by which emissions effectiveness data were to be developed. Key mode operation was employed as an engine diagnostic tool and as a reference to be utilized in developing additional emissions data*. The California Warm Vehicle Driveability Evaluation Procedure was used with respect to certain of the tasks to measure and compare objectionable vehicle operating characteristics. To transfer, process and analyze data generated by the study, both standard and specially designed procedures and methods were employed.

4.3 TEST VEHICLES

The Colorado light-duty vehicle population is comprised of nearly 1.1 million vehicles. This figure is reported in current registration data compilations. Of this number, nearly 60 percent are registered in the Metro-Denver area. In developing the test sample it was assumed that distribution in the

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*Key mode emissions testing was employed to develop certain of the data for Volume III, Impact of Altitude on Vehicular Exhaust Emissions.

Metro-Denver area paralleled statewide distribution.

As discussed, program objectives dictated the general test area. The east-central portion of the Metro-Denver area was selected. With the test area defined, the task of sample selection and procurement remained. Sample requirements were then defined in greater detail.

4.3.1 Vehicle Sample Specifications

For reasons discussed, the sample was to be comprised of 1964-1973 model year vehicles. A sample of 300 vehicles was considered adequate to represent the population. With the segment and size fixed, a standard hierarchy of selection criteria was utilized to further define sample distribution. This hierarchy ranks the relative importance of specifications in the following order:

1. Model-year
2. Make
3. Engine size
4. Transmission type
5. Carburetor type

The task of selection by model-year and make was accomplished by employing the following approach.

A compilation of 1964-1973 model-year vehicles was referenced. A matrix was developed for the 1964-1973 model year population by model-year and make. The matrix was developed in terms of percent distribution and was increased by a factor of three to equate the sample to 300 vehicles (Table 1.). By rounding

MAKE	MODEL-YEAR										
	64	65	66	67	68	69	70	71	72	73	TOT
Ammo	1.17	1.07	0.99	0.88	0.82	1.08	0.75	1.48	1.43	1.43	11.10
Buic	1.36	1.51	1.56	1.59	1.94	1.54	1.48	1.20	1.15	1.15	14.48
Cadi	0.52	0.55	0.58	0.67	0.73	0.55	0.62	0.53	0.51	0.51	5.77
Chev	6.64	6.64	6.74	5.80	7.29	6.45	5.74	6.67	6.50	6.50	64.97
Chry	0.51	0.71	1.02	0.88	1.03	0.73	0.51	0.64	0.62	0.62	7.27
Dodg	1.31	1.67	1.82	1.42	2.01	2.05	1.69	1.96	1.89	1.89	17.71
Ford	4.39	6.74	6.98	6.22	5.25	6.48	7.66	8.55	8.31	8.31	68.89
Impe	0.08	0.07	0.06	0.10	0.08	0.08	0.06	0.04	0.04	0.04	0.65
Linc	0.12	0.14	0.19	0.19	0.18	0.27	0.21	0.26	0.24	0.24	2.04
Merc	0.83	1.05	1.15	1.71	1.42	1.39	1.15	1.49	1.47	1.47	13.13
Olds	1.45	1.60	1.82	1.85	2.07	1.72	1.56	1.48	1.42	1.42	16.39
Plym	1.37	2.18	2.23	2.04	2.47	2.42	2.19	2.82	2.75	2.75	23.22
Pont	1.93	2.25	2.40	2.70	3.17	2.38	1.73	1.54	1.49	1.49	21.08
Impo	1.20	1.36	1.75	2.38	3.13	3.27	3.04	5.90	5.58	5.58	33.19
TOTAL	22.88	27.53	29.29	28.44	31.59	30.42	28.38	34.57	33.43	33.43	300

Table 1. Relative Distribution of Light-Duty Vehicles

matrix data to the nearest whole number, the desired composition of the sample was easily determined. Test sample composition by model-year and make is shown in Table 2*.

MAKE	MODEL-YEAR										
	64	65	66	67	68	69	70	71	72	73	TOT
Ammo	1	1	1	1	1	1	1	1	1	1	10
Buic	1	2	2	2	2	2	1	1	1	1	15
Cadi	1	1	1	1	1	1	1	1	1	1	10
Chev	7	7	7	6	7	6	6	7	7	7	67
Chry	1	1	1	1	1	1	1	1	1	1	10
Dodg	1	2	2	1	2	2	2	2	2	2	18
Ford	4	7	7	6	5	6	8	9	8	8	68
Merc	1	1	1	2	1	1	1	1	1	1	11
Olds	1	2	2	2	2	2	2	1	1	1	16
Plym	1	2	2	2	2	2	2	3	3	3	22
Pont	2	2	2	3	3	2	2	2	1	1	20
Volk	1	1	2	2	2	2	2	2	3	3	20
Toyo	0	0	0	0	1	1	1	1	1	1	6
Dats	0	0	0	0	0	0	0	1	1	1	3
Opel	0	0	0	0	0	0	0	1	1	1	3
Volv	0	0	0	0	0	0	0	1	0	0	1
Total	22	29	30	29	30	29	30	35	33	33	300

Table 2. Distribution of Test Vehicle Sample

Since 1973 model-year registration figures were not compiled, data from 1972 model-year vehicles were utilized as a reference to establish 1973 model-year representation. Also, foreign made vehicle registrations are reported in a miscellaneous category. This segment (foreign made vehicles) was assumed to comprise 50 percent of miscellaneous vehicles. This assumption was tested with respect to data formulated by the EPA and was found to be correct. The balance of miscellaneous vehicles are comprised of fleet type vehicles including taxicabs (Checker Motors), recreational vehicles (Jeep, Bronco, Scout, etc.) and other vehicles of relatively low sales volume.

With distribution established by model-year and make, a further delineation was required. National data, with respect to engine sales, was referenced. These data appear to be representative of sales in the Denver AQCR +. Engines were selected for respective model-years and vehicle makes by proportional sampling (similar to that procedure employed to select sample by model-year and make). This procedure yielded the more popular engines by cubic inch displacement and excluded engines of relatively low sales volume. Table 3. shows engines tested with respect to those desired by displacement class.

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*Table 2 also indicates, with one exception, the distribution of vehicles actually tested. One of the Cadillacs, a 1965 model, was represented upon delivery by the owner to be a 1966 model. An audit of vehicle information later identified the vehicle as a 1965 model.

+Inferred from Figure 2.6 of the referenced study.

DISPLACEMENT CLASS (cubic inches)	NUMBER SELECTED	NUMBER TESTED
Less than 251	87	86
251-330	104	100
331-399	69	68
More than 399	40	46

Table 3. Distribution of Sample By Engine Size

National sales data relating to transmission type and carburetion is not regarded as applicable to the Denver area* and an extensive inquiry failed to turn up locally applicable data. Since these data were unavailable, no attempt was made to force the sample in this respect. It was deemed a more reasonable approach to allow the various transmission and carburetor types to be influenced by local factors than to force the sample to fit national data. It was assumed that local factors would be reflected in the random nature of procurement efforts.

4.3.2 Test Vehicle Procurement

Once the vehicle sample was defined, the next task was to procure selected vehicles for testing. A standard procurement procedure was employed to gain access to the population.

A local statistical and mailing firm, Hibbert Laman, was contacted. Laman was provided sample specifications. Since 1973 model-year data had not been published, the Colorado Department of Revenue was also contacted. The department furnished data with respect to 1973 model-year vehicle registrations.

Laman and the department supplied lists of vehicle owners residing in the test area. The area was defined by postal Zip Code and names were selected from computer files by a method of nth name selection. Selected names comprised a mailing list. Concurrent with the development of mailing lists, mailing materials were designed and printed.

Printed materials were developed and supplied to test candidates in three forms; an introductory letter provided by the State of Colorado, an introductory letter supplied by ATL, and a post-paid information reply card. (Figures 1, 2, and 3). Materials were assembled, stamped and mailed 10 days in advance of scheduled test start-up.

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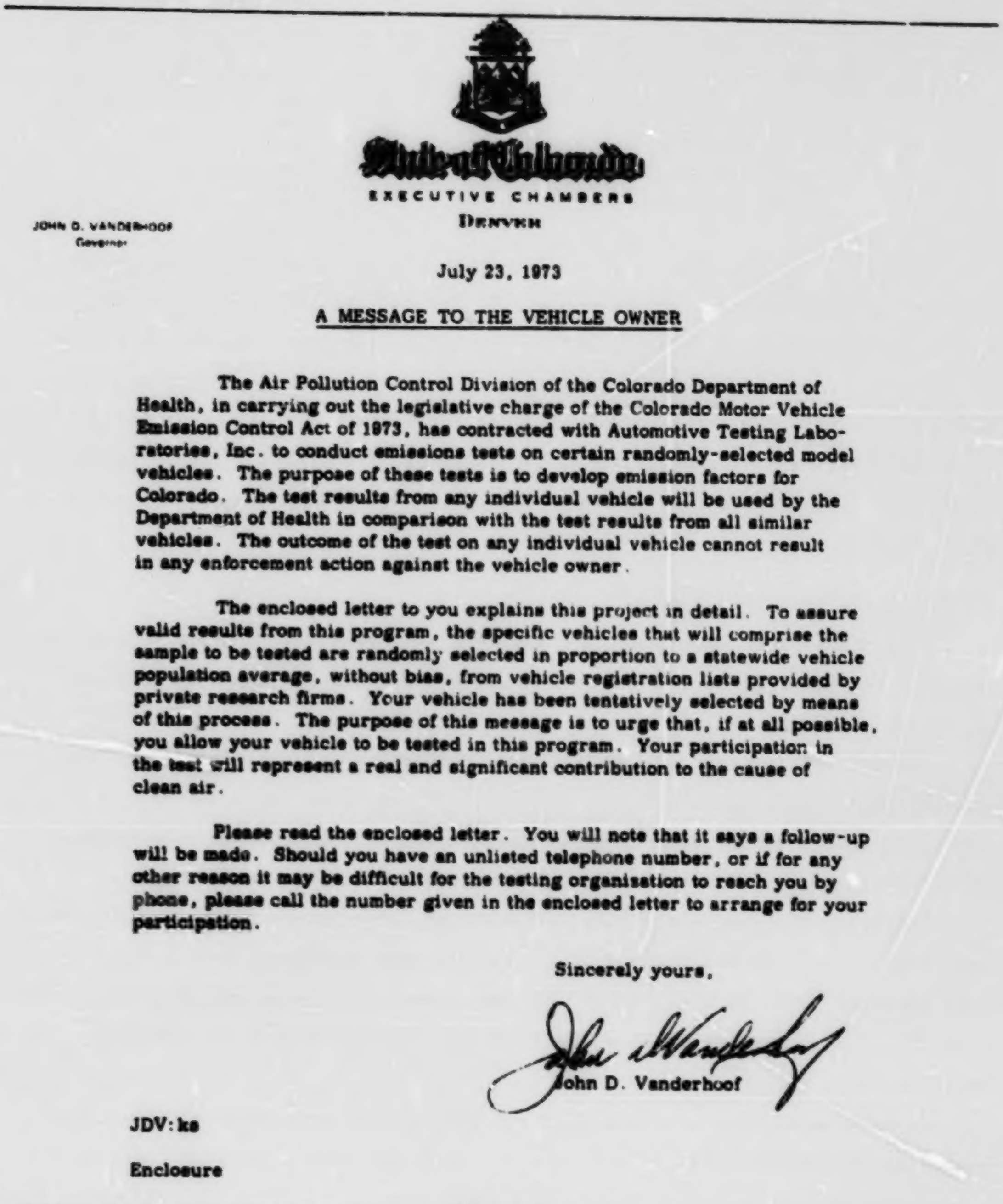
*Also inferred from Figure 2.6 of referenced study.



State of Colorado
EXECUTIVE CHAMBERS
DENVER

JOHN D. VANDERHOOF
Governor

July 23, 1973

A MESSAGE TO THE VEHICLE OWNER

The Air Pollution Control Division of the Colorado Department of Health, in carrying out the legislative charge of the Colorado Motor Vehicle Emission Control Act of 1973, has contracted with Automotive Testing Laboratories, Inc. to conduct emissions tests on certain randomly-selected model vehicles. The purpose of these tests is to develop emission factors for Colorado. The test results from any individual vehicle will be used by the Department of Health in comparison with the test results from all similar vehicles. The outcome of the test on any individual vehicle cannot result in any enforcement action against the vehicle owner.

The enclosed letter to you explains this project in detail. To assure valid results from this program, the specific vehicles that will comprise the sample to be tested are randomly selected in proportion to a statewide vehicle population average, without bias, from vehicle registration lists provided by private research firms. Your vehicle has been tentatively selected by means of this process. The purpose of this message is to urge that, if at all possible, you allow your vehicle to be tested in this program. Your participation in the test will represent a real and significant contribution to the cause of clean air.

Please read the enclosed letter. You will note that it says a follow-up will be made. Should you have an unlisted telephone number, or if for any other reason it may be difficult for the testing organization to reach you by phone, please call the number given in the enclosed letter to arrange for your participation.

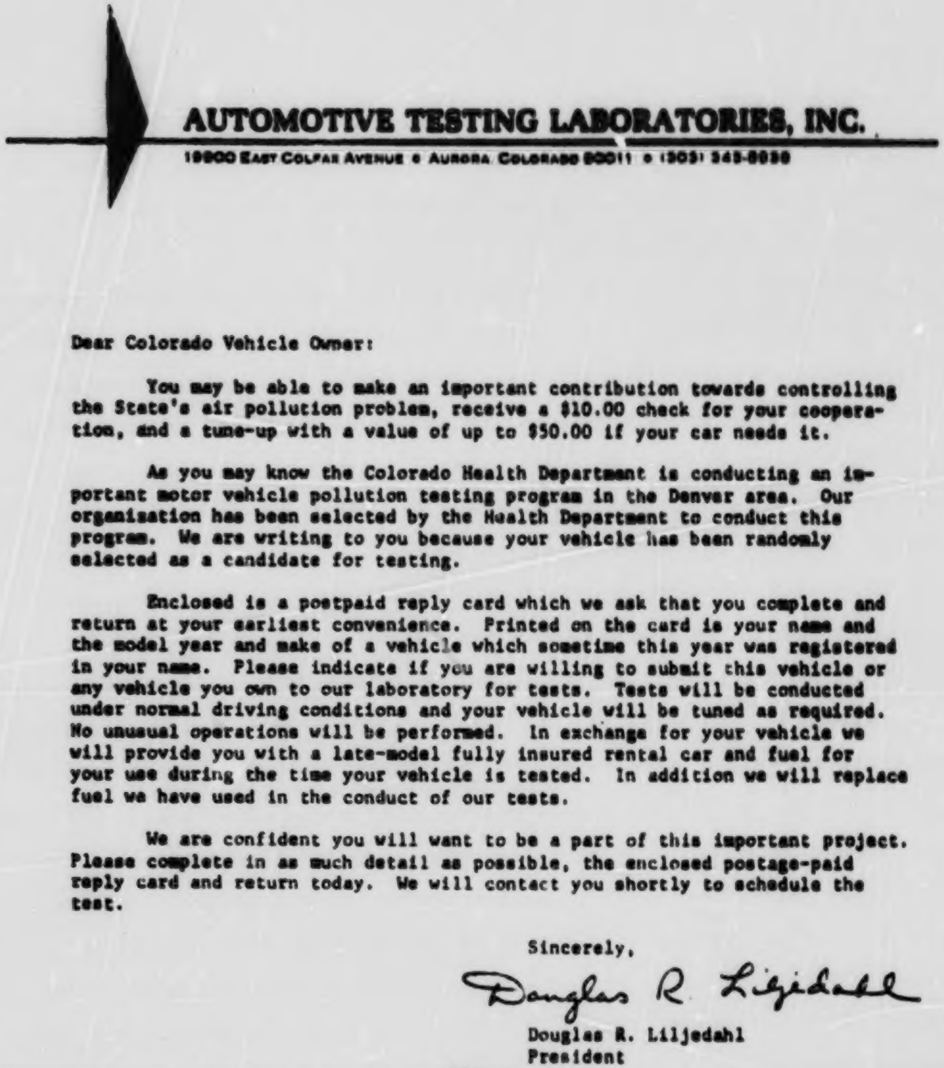
Sincerely yours,

John D. Vanderhoof

JDV:ks

Enclosure

Figure 1.



AUTOMOTIVE TESTING LABORATORIES, INC.
19900 East Colfax Avenue • Aurora, Colorado 80011 • (303) 343-8050

Dear Colorado Vehicle Owner:

You may be able to make an important contribution towards controlling the State's air pollution problem, receive a $10.00 check for your cooperation, and a tune-up with a value of up to $50.00 if your car needs it.

As you may know the Colorado Health Department is conducting an important motor vehicle pollution testing program in the Denver area. Our organization has been selected by the Health Department to conduct this program. We are writing to you because your vehicle has been randomly selected as a candidate for testing.

Enclosed is a postpaid reply card which we ask that you complete and return at your earliest convenience. Printed on the card is your name and the model year and make of a vehicle which sometime this year was registered in your name. Please indicate if you are willing to submit this vehicle or any vehicle you own to our laboratory for tests. Tests will be conducted under normal driving conditions and your vehicle will be tuned as required. No unusual operations will be performed. In exchange for your vehicle we will provide you with a late-model fully insured rental car and fuel for your use during the time your vehicle is tested. In addition we will replace fuel we have used in the conduct of our tests.

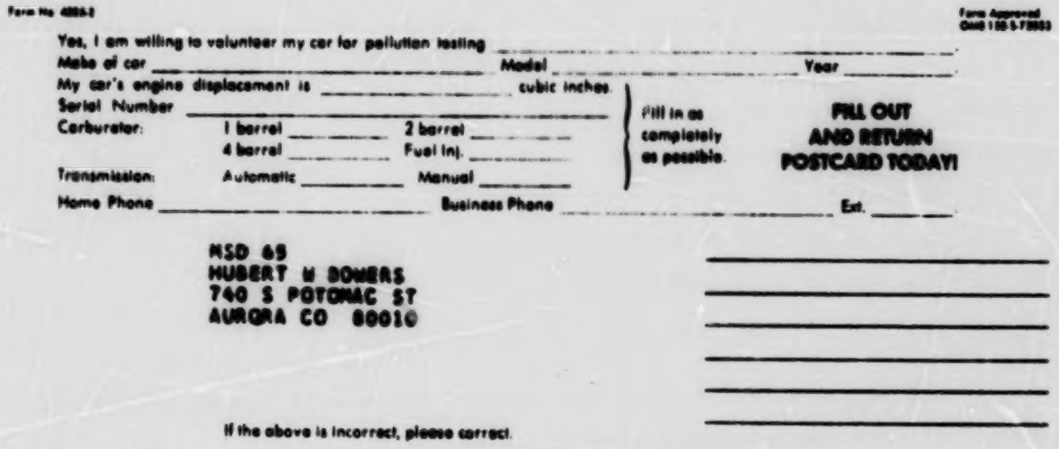
We are confident you will want to be a part of this important project. Please complete in as much detail as possible, the enclosed postage-paid reply card and return today. We will contact you shortly to schedule the test.

Sincerely,

Douglas R. Liljedahl

Douglas R. Liljedahl
President

Figure 2.



Form No [illegible]

Form Approved
OMB [illegible]

Yes, I am willing to volunteer my car for pollution testing ____________
Make of car ____________ Model ____________ Year ________
My car's engine displacement is ____________ cubic inches
Serial Number ____________
Carburetor: 1 barrel ________ 2 barrel ________
4 barrel ________ Fuel Inj. ________
Transmission: Automatic ________ Manual ________
Home Phone ____________ Business Phone ____________ Ext. ______

Fill in as completely as possible.

FILL OUT AND RETURN POSTCARD TODAY!

MSD 65
HUBERT W BOWERS
740 S POTOMAC ST
AURORA CO 80010

If the above is incorrect, please correct.

Figure 3.

Upon return of post-paid reply cards, a candidate vehicle file was established. The file, established by vehicle model-year and make, was later utilized for test scheduling.

A key element to obtaining a valid sample of vehicles is owner response; as owner response improves, the validity of the sample improves. Sample validity can be improved by employing a combination of carefully designed and executed procurement strategies. These can be described as comprising two elements; owner contact and incentives. Incentives provided by this program will be described in paragraph 4.3.3. The following discussion is offered to indicate the validity of the sample.

In all, 7500 names of vehicle owners residing in the test area were initially selected. Of the 7500 mailings, about 1200 were returned for various reasons, but primarily because owners had moved and left no forwarding address. In this respect it appeared that about 6300 mailings were delivered and presumeably received candidate review. Of materials delivered, about 1700 or 27 percent were returned to ATL expressing an affirmation of interest. This rate of return is considered to be excellent when compared to the normal return rate of 5 to 10 percent experienced in similar procurement programs. The unusually high rate of return is probably due to the evidence of support from the Governors office (introductory letter) and the Department of Health (news releases), a high level of public interest, the incentive program and other factors.

4.3.3 Incentives

A major factor in the success of a procurement plan is the incentive program. To enhance the program in this respect, several incentives were offered and are listed as follows:

1. A check in the amount of 10 dollars.
2. Up to 50 dollars in engine maintenance.
3. The loan of a late-model car.
4. Fuel for the loan car.

Checks were provided to test participants and were delivered immediately after individual vehicle tests were completed.

Some maintenance was performed on all cars except those which initially passed the idle emission test and were not further utilized for retrofit and modification sub-samples. More extensive maintenance was performed on sub-sample vehicles.

Leased 1973 model-year vehicles of intermediate size were furnished to participants at no charge. Loan cars were issued upon delivery of test vehicles to the laboratory and were provided by way of a contractual agreement with Dollar-A-Day Systems, Denver. All but a relatively small number of participants required loan cars.

Fuel for loan vehicles was also provided. A major segment of the project was performed during the summer and early fall months when gasoline was in short supply in the Denver area. By way of assistance provided by the Department of Health, a contact was established with one of the major oil companies. Additional fuel was provided from this source through a purchase agreement to supplement fuel deliveries via normal supply channels. An average of about four gallons of fuel per day was provided to participants for loan vehicles. Fuel consumed for testing purposes was replaced.

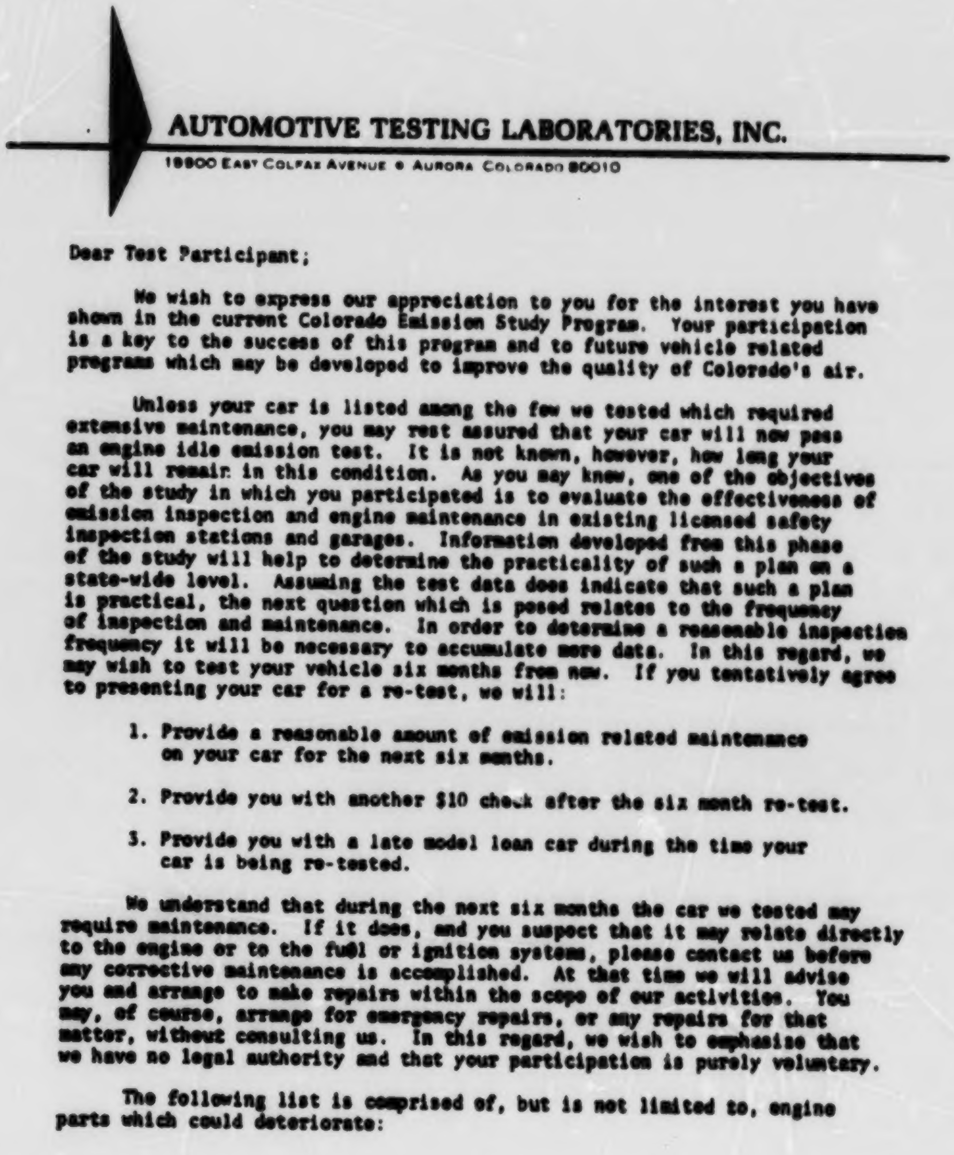
4.3.4 Initial Vehicle Acceptance and Handling

Nearly all vehicles comprising the 300 car sample were delivered to the laboratory for testing. In a few isolated instances, where an owner found it inconvenient to deliver a vehicle, laboratory personnel made the pick-up.

Prior to acceptance for testing, vehicles were inspected by laboratory personnel. Inspections were performed to reduce potential laboratory liability with respect to existing dents, scratches, broken windows, missing equipment, etc. and to ascertain general vehicle condition with respect to safety and exhaust system integrity. Approximately 7 percent of vehicles inspected were rejected for both safety reasons (2 vehicles) and excessive exhaust system leakage (19 vehicles).

Upon acceptance, contracts between the laboratory and the vehicle owner were executed. Contracts outlined laboratory and owner liability with respect to both the loan car and the test vehicle. Since many of the test vehicles were utilized for more than one task, a packet of materials was assigned to each vehicle. These packets contained routing and data forms consistent with the respective tests to which the vehicle was assigned.

When vehicle testing was completed, the owner was notified and the vehicle was scheduled for pick-up. Certain engine components and adjustments were identified and sealed in preparation for subsequent recall in the degradation study. When the owner arrived for pick-up, a final inspection was completed and the vehicle was released to its owner. Upon acceptance by the owner, the owner was informed of the potential recall in the form of a letter from ATL (Figure 4).



AUTOMOTIVE TESTING LABORATORIES, INC.
19900 East Colfax Avenue • Aurora Colorado 80010

Dear Test Participant;

We wish to express our appreciation to you for the interest you have shown in the current Colorado Emission Study Program. Your participation is a key to the success of this program and to future vehicle related programs which may be developed to improve the quality of Colorado's air.

Unless your car is listed among the few we tested which required extensive maintenance, you may rest assured that your car will now pass an engine idle emission test. It is not known, however, how long your car will remain in this condition. As you may know, one of the objectives of the study in which you participated is to evaluate the effectiveness of emission inspection and engine maintenance in existing licensed safety inspection stations and garages. Information developed from this phase of the study will help to determine the practicality of such a plan on a state-wide level. Assuming the test data does indicate that such a plan is practical, the next question which is posed relates to the frequency of inspection and maintenance. In order to determine a reasonable inspection frequency it will be necessary to accumulate more data. In this regard, we may wish to test your vehicle six months from now. If you tentatively agree to presenting your car for a re-test, we will:

1. Provide a reasonable amount of emission related maintenance on your car for the next six months.
2. Provide you with another $10 check after the six month re-test.
3. Provide you with a late model loan car during the time your car is being re-tested.

We understand that during the next six months the car we tested may require maintenance. If it does, and you suspect that it may relate directly to the engine or to the fuel or ignition systems, please contact us before any corrective maintenance is accomplished. At that time we will advise you and arrange to make repairs within the scope of our activities. You may, of course, arrange for emergency repairs, or any repairs for that matter, without consulting us. In this regard, we wish to emphasize that we have no legal authority and that your participation is purely voluntary.

The following list is comprised of, but is not limited to, engine parts which could deteriorate:

1. PCV system
2. Carburetor including air/fuel mixture and speed adjustments
3. Air Filter and/or filter element
4. Spark Plugs
5. Distributor parts including points and condensor, and timing and dwell adjustments
6. Spark Plug wires
7. Air pump and air injection system if so equipped
8. NO_x emission control system (1973 model-year only)

Many of the usual preventative maintenance procedures have no affect on emissions and may be attended to without consulting with us. These are:

1. Battery
2. Charging system
3. Oil filter replacement
4. Oil changes
5. Lubrication

If there is any doubt as to the impact maintenance may have on the program, however, please do not hesitate to call us at 343-8938. We will respond promptly.

Again, we wish to express our appreciation for your participation. Hopefully, the data which we are developing as a result of your cooperation will lead toward cleaner air in Colorado.

Gratefully yours,

Douglas R. Liljedahl
President

Figure 4.

4.4 LABORATORY TESTING AND EVALUATION PROCEDURES

The study was designed to determine the effectiveness of various emission control strategies and resulting side affects. To do so, testing and evaluation procedures were required. Key mode emissions testing was included in the testing and evaluation sequence solely for engine diagnostic purposes and as a tool to develop data for an altitude emissions study*. It was not under investigation as an alternate to idle emissions inspection. The following paragraphs describe the procedures selected and employed.

4.4.1 Exhaust Emissions Test Procedures

Three procedures were utilized; the Federal mass emission test procedure, a key mode (Clayton Mfg. Co.) test procedure, and an idle test procedure. The idle test procedure was utilized in the laboratory as a strategy to monitor safety inspection stations.

*Volume III of subject study, Impact of Altitude on Exhaust Emissions.

4.4.1.1 Federal Test Procedure

Laboratory standard exhaust emission tests were performed according to procedures stipulated in the Federal Register, Volume 38, Number 124, Part III dated June 28, 1973. As stipulated, emission tests were preceeded by a minimum 12 hour temperature soak at laboratory ambient temperature conditions (68 to 72°F, controlled by laboratory heating and air conditioning systems).

Prior to the first test of the day, the dynamometer was temperature stabilized using a non-test vehicle. Vehicles were pushed or towed onto the dynamometer for cold start tests as prescribed. Dynamometer load settings were established prior to cold starts using a non-test vehicle. Drive tires were inflated to 40 psi and devices to restrain the vehicle during testing were installed. An engine cooling fan was situated to the front of the vehicle to provide cooling to the radiator and underhood. An auxiliary 2 1/2 ton air conditioner was utilized to maintain cooling air at constant temperature during peak temperature loading conditions.

Immediately preceeding vehicle start up, constant volume sampler (CVS) bags were evacuated and CVS blower revolution counters were re-set to zero. To alert the test operator to test start-up a switch was activated to start the data acquisition system clock. Simultaneously the engine was cranked and the cold transient segment of the test began.

At the 505 second point of the driving schedule the instrument operator was again alerted signalling the end of the cold transient segment and the start of the cold stabilized segment of the test. The instrument operator responded by diverting exhaust and background sample flow into the cold stabilized sample bags. Composition of the cold transient bag was then analyzed and stored by the data acquisition system on computer punch tape for subsequent processing.

The driving schedule was continued to the end of the 1372 second Federal test cycle. Two seconds prior to cold stabilized sampling termination, the engine was shut down. Cold stabilized sample composition was then analyzed and stored on punch tape for processing.

Upon termination of the cold stabilized segment, the CVS exhaust collector tube was disengaged from the vehicle tailpipe, the vehicle cooling fan was shut down and the engine compartment hood was closed. The vehicle was then allowed to hot soak for a period of 10 minutes.

Following the 10 minute interval, the exhaust collector tube was connected to the vehicle tailpipe, the vehicle hood was opened, the fan was started and the hot transient segment of the test was begun. Sampling continued to the 505 second point in the driving schedule, at which time the instrument operator was again alerted. Sample flow was diverted and the composition of the hot transient sample bags was analyzed and recorded on punch tape. At this point the mass emission test was complete.

4.4.1.2 Key Mode Test Procedure

Key mode tests were performed in accordance with procedures outlined by Clayton Manufacturing Company of El Monte, California. Key mode emission tests were performed on all vehicles at all test conditions for reasons already discussed and to be discussed in more detail in Volume III.

Key mode emissions testing followed the Federal mass emission test. Tests were performed from a hot engine start as recommended. Testing was performed at speeds and loads shown in Table 4. (It should be noted that the loads utilized for key mode testing were not corrected for frictional losses internal to the dynamometer. These losses were measured by the coast down technique for dynamometer calibration at about 4 horsepower. In this respect the loads indicated in Table 4. can be increased by 4 hp to determine actual loading during key mode operation.).

MODE	VEHICLE WEIGHT (lbs)	VEHICLE SPEED (mph)	DYNAMOMETER LOAD (hp)
High Cruise	Over 3800	49	29
	2800-3800	45	23
	Under 2800	37	14
Low Cruise	Over 3800	33	11
	2800-3800	30	9
	Under 2800	23	5
Idle	-	-	-

Table 4. Key Mode Operation

During key mode operation, exhaust emissions were measured directly from the tailpipe of the vehicle under test. Emissions measurements were performed utilizing the variety of instrumentation shown in Table 5. Since key mode emissions were not collected in sample bags, a standard analytical procedure was employed.

EXHAUST CONSTITUENT	INSTRUMENTATION PRINCIPLE	INSTRUMENTATION QUALITY	UNITS OF MEASUREMENT
CO	NDIR	LAB	Mole %
CO	NDIR	GARAGE	Mole %
HC	FID	LAB	ppm Carbon
HC	NDIR	LAB	ppm Hexane
HC	NDIR	GARAGE	ppm Hexane
NO	CHMLMNSCNT	LAB	ppm NO
CO_2	NDIR	LAB	Mole %

Table 5. Key Mode Analytical Instrumentation

The vehicle was operated at prescribed speed during which time the analytical system recorders were allowed to run. During this interval (normally about one minute), the instrument operator observed the pen traces for an indication of emission stabilization. This period was also utilized to diagnose the recorded hydrocarbon (HC) traces as a function of engine performance. Abnormal indications in hydrocarbon levels were recorded on engine diagnosis sheets. When emission levels appeared to be stable, the instrument operator activated a switch which signalled the data acquisition system (DAS) the sampling period had started. Sampling of tailpipe emissions continued for about 30 seconds. At termination of the sampling interval, the DAS was again alerted. The DAS then performed an integration of emission levels and a punch tape was produced for further processing.

In addition to the analytical system and DAS, other equipment was employed for key mode operation. A fan provided cooling air to the radiator and underhood of the vehicle. An engine tachometer was used to monitor and record engine rpm and dynamometer meters were utilized to operate the vehicle at prescribed speeds and loads.

4.4.1.3 Idle Test Procedure

Since one of the modes of key mode testing includes an emissions measurement at idle, idle test procedures were integrated with key mode testing. In addition to emission measurements at curb idle (Drive gear for automatic transmission equipped vehicles) a no-load emissions measurement was performed at 2500 engine rpm. Analytical procedures were similar to those applied for key mode testing. The engine was first operated at the prescribed condition until emissions stabilized. The sample, obtained over a 30 second interval, was then integrated by the DAS. Data was stored on punch tape for subsequent processing. Emission analytical instrumentation employed during idle emissions inspection were identical to that shown for key mode operation (Table 5.).

Idle emissions testing was performed under laboratory conditions as a means of monitoring the field inspections performed by selected licensed safety inspection stations. Inspection station emission data was compared at regular intervals to idle emission data developed in the laboratory. Employment of this monitoring strategy provided an effective means of early detection of personnel and instrumentation operational problems.

4.4.2 Driveability Evaluation Procedure

The California Warm Vehicle Driveability Evaluation Procedure* was used to evaluate certain of the emission control strategies with respect to driveability and performance. Evaluations were performed using tank fuels (fuels provided with test vehicles).

In the course of evaluation, the vehicle is operated at curb idle (neutral and/or drive gear), at various part throttle and wide open throttle acceleration rates, and at several road load or cruise conditions. During the various operating modes, a trained driver operates the vehicle and identifies objectionable driving characteristics. Objectionable characteristics are rated as to severity and quantitively defined through application of a weighted demerit system. During this procedure hot start engine cranking time is recorded along with the number of false starts noted during engine cranking and stalls during idle and off-idle operating modes.

A segment of the procedure also relates to engine performance. Engine performance is determined by accelerating the vehicle at wide open throttle from 0 to 70 miles per hour. Elapsed time (E.T.) during the acceleration interval is measured with a stop-watch. Data reported is an average of two sets of E.T. data derived from each of two opposing directions.

Engine braking characteristics are also measured as part of the driveability evaluation procedure. Elapsed time is recorded during closed throttle

*Formerly the Automobile Manufacturers Association (A.M.A.) Procedure.

operation from 70 to 30 miles per hour. Data reported is an average of two data sets derived from each of two opposing directions.

4.4.3 Fuel Consumption (Economy) Determination

Fuel economy (miles per gallon) data was developed for the mileage interval accumulated by the vehicle during Federal driving schedule operation. Data was obtained for the cold transient, cold stabilized and hot transient segments of the test and mathematically combined to yield a single miles-per-gallon figure.

The Federal driving schedule (1975 Procedure) is a 11.15 mile trip of 31 minutes and 17 seconds driving time. The schedule is interrupted after the first 7.5 miles for a 10 minute soak interval. During this time the engine is shut-down. The schedule was designed to simulate vehicle operation in a metropolitan area. A segment of the time-speed profile of the schedule is presented in Figure 5.

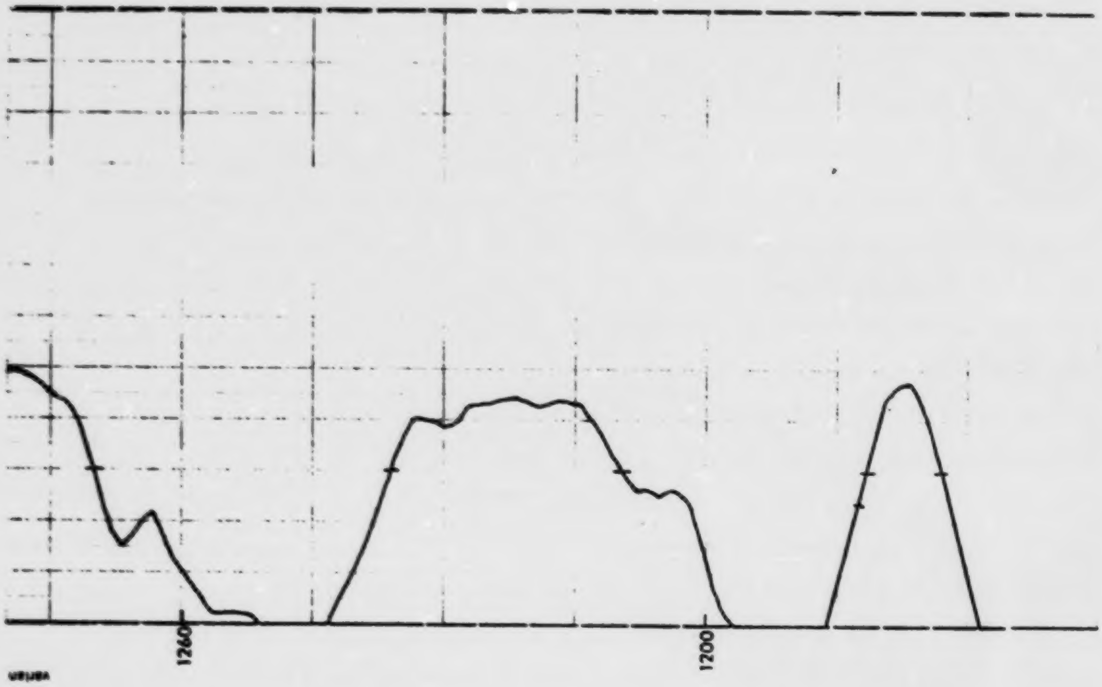


Figure 5.

Fuel economy data was obtained through application of a carbon balance equation[3] which takes into account the carbon content of emissions measured in the CVS exhaust and background sample bags. The fuel economy equation is based on a fuel hydrogen/carbon ratio of 1.85. The equation is as follows:

$$\text{MPG} = \frac{2808 \text{ grams fuel/gal} \times \frac{12.011}{13.875}}{\text{HC grams/mile} \times \frac{12.011}{13.875} + \text{CO grams/mile} \times \frac{12.011}{28.01} + CO_2 \text{ grams/mile} \times \frac{12.011}{44.01}}$$

where:

12.011 = molecular weight of carbon

13.875 = molecular weight of carbon + 1.85 x (H=1.008)

28.01 = molecular weight of CO

44.01 = molecular weight of CO_2

As indicated, the equation applied assumes a fuel hydrogen/carbon(H/C) ratio of 1.85*. To maintain uniformity in this respect over the entire program, a quantity of summer grade premium fuel was utilized for emissions testing+. Fuel was introduced to the engine via an auxiliary tank. A hydrogen/carbon ratio determination was not performed although prior analysis indicates the vendor supplied summer-grade fuel to vary from an H/C ratio of 1.84 to 1.87. Examination of the equation in this regard indicates the possible error to be less than ± 0.5 percent.

4.5 LABORATORY FACILITIES AND EQUIPMENT

The following paragraphs describe the facilities provided and the test equipment employed in the conduct of the study.

4.5.1 Physical Description of Facilities

Laboratory tests were performed in ATL facilities situated at 19900 East Colfax Avenue, Aurora, Colorado. The laboratory is located at an elevation of 5,390 feet above mean sea-level.

The laboratory is housed in a building containing about 1600 square feet of office area and 8000 square feet of laboratory and shop area. A total of

*The equation is based on the H/C ratio of Indolene 30, a standard test fuel.

+A batch of this fuel was set aside for subsequent application for the emissions degradation study.

22 1/2 tons of air conditioning is provided in laboratory areas to maintain ambient air temperatures well within the limits prescribed for emissions testing. Space is available to temperature soak up to 18 vehicles simultaneously.

Two complete equipment and instrumentation sets, both capable of testing by the 1975 EPA procedures are provided. One set was used exclusively for conduct of the subject study. In addition, supplementary engine monitoring and tune-up equipment was utilized.

4.5.2 Constant Volume Sampler

The constant volume sampler (CVS) designed and constructed by Automotive Environmental Systems, Inc. of Westminister, California is of a nominal 325 cfm flow capacity. The CVS mass pump is driven by a line synchronous, 240 volt, 5 hp motor through a gear-belt arrangement. A count of blower revolutions is generated by a magnetic pick-up and displayed on an electical digital counter. Dilute exhaust temperature is maintained by a gas to water heat exchanger with control functions modulated by a temperature controller. The CVS is equipped with two sets of exhaust and backgound sample bags. Dilution air is provided through a filtration system comprised of absolute particle and charcoal filters.

Prior to testing, the CVS was flow calibrated. A Meriam laminar flow element, Model 50, rated at 1000 cfm at 8 inches of water differential pressure, was utilized to determine CVS flow rates. Auxiliary devices; a mercury barometer, U-tube water and mercury manometers, an inclined water manometer and thermometers were utilized to observe test conditions. Mass flow through the laminar flow element was calculated as follows:

$$V_{LFE}\ \mathrm{SCFM} = \mathrm{ISCFM} \times T_{LC} \times \frac{P_L\ ''H_2O}{406.8''H_2O}$$

where:

V_{LFE} SCFM = absolute flow rate of the laminar flow element in standard cubic feet per minute

I SCFM = indicated flow rate of the laminar flow element in standard cubic feet per minute

T_{LC} = temperature correction factor

$P_L''H_2O$ = inlet pressure to the laminar flow element in inches of water

and:

$406.8''H_2O$ = standard absolute pressure in inches of water.

The laminar flow element calibration is traceable to flow standards of the National Bureau of Standards.

With V_{LFE} SCFM established, CVS mass pump flow rate was calculated in cfm as follows:

$$V_o = \frac{V_{LFE}\ SCFM}{Rpm} \times \frac{406.8''H_2O}{P_p''H_2O} \times \frac{T_p\ ^oR}{530^oR}$$

where:

V_o = volume of the mass pump in scfm per revolution

V_{LFE} SCFM = volume of laminar flow element in scfm

Rpm = mass pump rpm

$406.8''H_2O$ = standard absolute pressure in inches of water

$P_p''H_2O$ = mass pump inlet pressure in inches of water

$T_p\ ^oR$ = mass pump inlet temperature in degrees absolute

530^oR = standard absolute temperature in degrees absolute.

Blower inlet flow rates were determined at several incremental changes in mass pump inlet pressures (P_p) and mass pump differential pressures (Δ_p). Data were then compared with previous inlet and outlet flow rates and plotted. Mid-range P_p and Δ_p were determined and the corresponding V_o was selected to be utilized in mass emissions calculations.

As an additional check of the blower flow rate calibration, propane recovery tests were performed. Propane recovery tolerances of ± 2 percent were attained and the initial CVS calibration was completed.

A propane recovery test is a technique employed to examine the CVS and emissions analytical system. A weighed quantity of propane is injected into the CVS exhaust collector tube. With the CVS in operation, a sample of injected propane is simultaneously collected in the sample bag and analyzed. Results of this analysis are used to calculate the amount of propane recovered in the CVS sample system. Recovery values are compared with the weighed injected value. Recovery within ± 2 percent of the quantity injected is an acceptable tolerance. Propane recovery tests were performed on a daily basis for the duration of the program to verify testing accuracy.

4.5.3 Emission Analytical Console

An analytical console, designed and constructed by ATL was used to measure and record exhaust emission levels. The console is comprised of the following major test equipment:

Beckman Model 315A NDIR CO analyzer with stacked cell arrangement, 6 range capability and optical CO_2 interference filter.

Beckman Model 315B NDIR CO_2 analyzer with 3 range capability.

Beckman Model 400 Hydrocarbon Flame Ionization detector with 4 range capability.

Thermo-Electron Model 10A Chemiluminescent NO and NO_x analyzer equipped with thermal converter and 8 range capability.

Texas Instrument 2 and 3 channel potentiometric 10 inch recorders.

Flow control and directional valves and flow rate indicators for introduction and flow control of zero, span and sample gases.

A refrigerated ice bath and filter system for sample gas conditioning.

The analytical console was designed and constructed in accordance with specifications prescribed in the Federal Register. Because of the relatively high emission levels expected to be encountered, console modifications for drying emission samples and absorbing CO_2 from the CO sample stream were not provided.

In view of the specific requirements of the study, a supplemental analytical console was also utilized. The console was equipped with a Beckman 315A NDIR hydrocarbon analyzer, a Texas Instruments potentiometric recorder, and flow and directional control valves, flow rate indicator, and sample conditioning system.

Prior to test start-up, the analytical system was calibrated at a minimum of five points for each operating range. Calibrations were performed using gaseous standards traceable to standards of the EPA Laboratories in Ann Arbor, Michigan. Best fit calibration curves were established with curve fit tolerances maintained within ± 2 percent of gaseous standard concentrations.

During the testing phase, mid and high range calibration points were checked and verified for compliance with calibration standards on a weekly basis. Complete analytical system calibrations were performed and verified at monthly intervals. Up-scale calibration points were established both before and after analysis of each exhaust sample. CVS and analytical system plumbing was verified to be free of leaks and in good operating condition on a daily basis. In addition, the thermal converter of the chemiluminescent $NO-NO_x$ analyzer was tested and verified for proper operating efficiency on a daily basis.

4.5.4 Data Acquisition System

To provide for the orderly accumulation and processing of emissions data, a data acquisition system (DAS) was utilized. The system is comprised of a Data General, Nova 1200, mini-computer, connected through a multiplexer to the analytical instrumentation. Each analyzer is equipped with range encoding devices which transmit range code signals to the computer. Analytical instruments from both the CVS analytical console and the supplemental NDIR hydrocarbon console are wired to the system.

Although the DAS is capable of modal analyses under transient emissions monitoring conditions, it was utilized solely to collect, process and record CVS collected bag emission data and emissions monitored during steady state operation (key mode and idle). Analyzer signals are sampled at a rate of 10 times per second and temporarily placed in storage. At termination of the 30 second sampling interval, accumulated analyzer signals are integrated by the Nova computer, range signals are decoded and both instrument range and integrated sample data is output on a teletype machine. DAS output data is then input to a time-share computer, Service Bureau Corporation, Call 370, for processing. CVS emissions data were processed in accordance with calculation procedures of the Federal Register. Key mode and idle emissions data are output in terms of mole percent or parts per million as applicable.

Prior to test start-up, the operation of the DAS was qualified with respect to range encoding and interpretation and print-out of respective analyzer output signals. Thereafter, DAS calibration and performance were checked and verified on a daily basis.

4.5.5 Chassis Dynamometer

A Clayton Manufacturing Company, Model CT-200, chassis dynamometer was utilized to load the vehicle during CVS and key mode emission testing. The dynamometer has been modified to improve the sensitivity and resolution of load settings. A low scale meter and torque bridge is installed.

Prior to testing, a dynamometer calibration was performed. The dynamometer was initially calibrated for proper speed indication. A line synchronous strobe light was utilized to relate roll speed to a true speed meter indication. A dead weight calibration was then performed using a Clayton-built calibration kit. Dynamometer internal power losses were then determined by the Federal Register coast-down technique. An indicated versus actual horsepower calibration table was developed from coast-down data and was utilized by the vehicle operator to establish load settings for CVS testing operations. During the testing phase coast-down calibrations were performed and verified at monthly intervals.

4.5.6 Laboratory Application of Garage Instrumentation

Sun Electric Company, Model EPA-75, non-dispersive infrared instruments were supplied to the 10 selected inspection stations. In addition, two instruments were utilized in the laboratory. One was provided for retrofit installation and adjustment purposes. The other was utilized in key mode and idle emissions inspection to monitor the quality of garage inspection. The EPA-75 measures carbon monoxide and hydrocarbons and is equipped with two ranges of sensitivity for each exhaust constituent. The unit also incorporates a sample conditioning system (particulate filter and condensate trap), a sample pump and flow rate indicator and an indicating light to warn of sample flow restriction.

Each of the EPA-75 instruments was calibrated across the entire operating range prior to test start-up. Gaseous carbon monoxide and hydrocarbon standards were used. Instrumentation was checked for proper calibration at two week intervals through the testing phase of the program. In addition, a pre-test calibration was required at the inspection station level prior to the performance of emissions inspection. Calibration at the station level did not employ a reference to gaseous standards, but rather a reference to an electrical zero and up-scale check point.

4.5.7 Laboratory Standard Calibration Gases

A variety of gaseous standards was applied to establish standardized analytical instrumentation response curves. A listing of gaseous standards is shown in Table 6. The gases shown are traceable to standards of the EPA Laboratories in Ann Arbor, Michigan.

4.5.8 Miscellaneous Equipment

During the course of the program, a variety of garage-type engine tune-up equipment was utilized to maintain and prepare vehicles for testing. The

HC(ppmC)				
39.6	250.5	978.0	5619.0	19906.0
58.2	322.2	1263.0	5772.0	56295.0
108.0	513.0	1909.5	7068.6	
109.5	592.5	2957.0	8045.0	
CO(mole %)				
0.0172	0.2061	0.65	2.98	9.83
0.0511	0.2078	1.01	3.22	11.58
0.0607	0.2977	1.02	3.73	
0.0984	0.3103	1.13	5.53	
0.1064	0.3963	1.67	7.65	
0.1797	0.5500	2.07	7.71	
CO_2(mole %)				
0.4373	3.0275	3.63	7.95	11.08
0.6042	3.0800	4.08	8.00	11.92
0.9940	3.1100	4.82	8.93	13.87
2.0462	3.4100	5.56	10.25	
NO_x(ppm)				
32	109	204	411	785
49	178	250	523	974
98	191	324	695	1188

Table 6. Concentrations of Gaseous Project Standards

equipment assortment is comprised of various ignition timing lights, engine tachdwellmeters and pressure and vacuum gauges as would normally be required in the performance of maintenance and tune-up work. Prior to utilization in the program, tune-up support equipment was sent to respective manufacturer's repair facilities for check-out and calibration.

4.6 DATA HANDLING

The following discussion describes the system designed and utilized to collect test results and other pertinent data, the techniques employed to insure validity of the data, and the methods of data reduction.

4.6.1 Data Collection

To provide an orderly and efficient method of accumulation and handling of data, flow charts of all possible testing sequences were constructed. During testing sequence design, primary consideration was to develop a maximum amount of data with a minimum number of tests. (Flow charts developed for a minimum of tests are presented in Appendix 1).

The next task in order was the design of each of the various forms required to collect the data. Since a vehicle would be subjected to varied tests and inspections several data forms were designed. These are shown in Appendix 2 and are described as follows:

1. Vehicle Information - containing designated test sequence, vehicle number (ATL), equipment and test information.

   Vehicle Inspection - showing status of incoming vehicle with respect to its general physical condition (dents, scratches, etc.), owner identification and block for signature to indicate owner acceptance of initial inspection.

   Condition When Returned - showing outgoing odometer reading and owner acceptance of outgoing vehicle.

2. Emission Test - showing existing test conditions (barometer, dry and wet bulb temperature, etc.)

   Federal mass emission test data

   Key mode and idle emission test data

   Key mode and idle diagnostics

3. Maintenance Status Information - showing the condition of emission related components, parts and adjustments, both before and after garage inspection and maintenance.

4. Inspection Station Results - showing initial emission results of garage inspection and results after adjustment of idle rpm, ignition timing, idle mixture, and other maintenance as required. Cost information at the garage level is also reported for inspection and maintenance.

5. Warm Vehicle Driveability Test Form - indicating presence and severity of adverse driving characteristics and other vehicle performance data.

In the conduct of the study a packet of forms, as applicable to a given test sequence, was assigned to each vehicle. These packets were designed to govern vehicle flow through respective testing sequences. Forms accompanied test vehicles to the soak area to await testing.

During the emission test sequence analyzer ranges and millivolt output, corresponding to emission concentrations, were collected by the DAS. CVS blower revolutions, pump inlet pressure depression and Sun analyzer key mode emission data were observed by the instrument operator and recorded on raw data forms. Ambient test information was recorded both on test forms and logged in the DAS via teletype communication. Certain test parameters; blower counts, inlet pressure and Sun analyzer readings were not programmed for automatic collection by the DAS. These data were manually punched on paper tape using a remote teletype unit.

Upon completion of emission tests, the condition of various engine components, component parts and adjustments was ascertained by various inspection techniques. Inspection results were entered on the appropriate section of the Maintenance Status Inspection form (As Received from Owner). The first set of emission and maintenance status data comprised all data required prior to delivery of the vehicle for garage idle inspection. The vehicle was then transferred to the garages for idle emission inspection.

For garage inspection, an Inspection Station Results form and an engine adjustment specifications sheet were provided. At the garage, inspectors performed a totally independent inspection. The inspection was performed without knowledge of laboratory idle emission inspection results. Inspections were generally performed in accordance with the Idle Test Procedures for Participating Garages (Appendix 3) following guidelines presented at inspector and mechanic training sessions. An inspection was performed by the (arbitrarily designated) inspector and required maintenance was performed by the (arbitrarily designated) mechanic. Garage inspection data, including costs, were recorded on the Inspection Station Results sheet.

Upon completion of garage inspection, the vehicle was returned to the laboratory. Garage inspection forms were then reviewed. If initial garage inspection indicated the vehicle failed, a re-test was scheduled and the vehicle was returned to the soak area. Following the soak interval, the vehicle was subjected to re-test by Federal mass, key mode and idle emissions testing procedures. A second maintenance status inspection was performed. Results of this inspection were indicated on the Maintenance Status Information form in the section titled, As Returned from Inspection Station. If a vehicle passed initial garage inspection, an emission re-test was not performed and the vehicle had now completed the idle inspection phase of the project. From this point, the vehicle was either returned to its owner or was further maintained in preparation for additional utilization in one of the vehicle sub-samples.

If additional testing of a given vehicle was required, an appropriate data sheet packet was assigned to the vehicle. Form packet distribution was compatible with the various tasks and related testing sequences to which the vehicle was assigned. The composition and description of each of the various form packets is shown in Table 7.

With respect to the various testing sequences, vehicles were routed in accordance with the requirements of each task. A testing sequence is a series

Test Sequence Assignment	Form Packet Composition
1. Idle Emission Inspection	1 Vehicle Information 2 Emission Test 1 Maintenance Status Information 1 Inspection Station
2. Tune-up Evaluation	1 Routing Sheet 8 Emission Test 8 Warm Vehicle Driveability Test
3. High Altitude Retrofit with Maintenance	1 Routing Sheet 2 Emission Test 2 Warm Vehicle Driveability Test
4. Sea Level Retrofit with Maintenance	1 Routing Sheet 2 Emission Test 2 Warm Vehicle Driveability Test
5. Sea Level and High Altitude Retrofits	1 Routing Sheet 3 Emission Test 3 Warm Vehicle Driveability Test
6. High Altitude Retrofit without Maintenance	1 Routing Sheet 1 Emission Test 2 Warm Vehicle Driveability Test
7. Sea Level Retrofit without Maintenance	1 Routing Sheet 1 Emission Test 2 Warm Vehicle Driveability Test

Table 7. Composition of Vehicle Routing and Data Collection Form Packets

of adjustments, equipment installations or removal, emissions tests, and driveability evaluations. Forms utilized to route vehicles through testing sequences are shown in Appendix 4.

Data collection and vehicle routing procedures have been described. Data was stored in the manner indicated until all tests on a given vehicle were completed. Stored data were then transferrred via remote teletype to the Service Bureau Corporation (SBC) Call 370 (Computer) System for processing. An intermediate step of proof reading and data audit is described next.

4.6.2 Quality Audit

A substantial quantity of data was collected and processed. To establish confidence in the conclusions resulting from the testing program, it was necessary to insure the reliability of the data. To attain a valid compilation of data, the potential for introduction of error via data collection and transmission techniques was minimized through a system of quality control and data audit. In short, measures were required to verify the validity of all accumulated data.

Integrity of analytical instrumentation was discussed in paragraph 4.5. With particular regards to the accuracy of data transmission, amplifiers connecting each analyzer to the data acquisition system were checked and adjusted each morning to insure that data collected by the DAS were in agreement with scale readings on the chart recorders. DAS output data were also compared at random intervals throughout the day for agreement with strip chart data.

When manually recorded data forms were completed, each form was scanned to verify that pertinent data had been collected and recorded. A further review was completed to verify that recorded data were in an acceptable form for introduction to the SBC Call 370 System. As forms were inspected and determined to be acceptable, the auditor indicated such by signing off in the appropriate quality audit block of the data form. Data was then punched on paper tape for introduction into computer storage. The data punch block of the quality audit was then signed off by the computer operator. Data were then entered into a temporary Call 370 file. Input data were listed out and reproofed to check and verify the quality of on-line data transmission and storage. Discrepancies in raw data files were then resolved and affected files were corrected. A computer edit program (Appendix 5) was then applied to stored data. The program was written to test and compare each data point to predetermined data tolerances. Data of questionable validity were output, descrepancies were resolved, and corrected data were entered into file. Upon completion of data audit procedures, data were transferred into a permanent file in preparation for processing.

4.6.3 Data Reduction

In the permanent file, emission data were processed as applicable. Federal mass emission data were processed in accordance with the Federal Register, Volume 38, Number 124, Part III, dated June 28, 1973. Results are expressed in terms of grams per mile for CO, CO_2, HC and NO_x emissions. Grams per mile data for CO, CO_2, and HC are then applied in the fuel economy equation and a miles per gallon figure is calculated. Liquified petroleum gas (LPG) fuel economy data were calculated using a hydrogen/carbon (H/C) ratio of 2.67 instead of the 1.85 H/C ratio applied for gasoline fueled vehicles. LPG fuel economy data were then converted to a gasoline equivalence and was reported as miles per gallon.

Key mode and idle emission inspection data were adjusted on a dry exhaust volume basis as outlined in the California Exhaust Emission Standards and Test Procedures for 1972 Model-Year Gasoline-Powered Motor Vehicles under 6,001 Pounds Gross Vehicle Weight. CO readings were reported in mole percent, NO_x was reported in parts per million, HC as measured by the FID principle was reported in parts per million as carbon. NDIR HC was reported in parts per million as n-hexane. Key mode and idle emission data obtained from the Sun EPA-75 required no reduction and were reported in mole percent for CO and parts per million as n-hexane for HC.

Driveability demerit ratings were manually recorded and calculated by the California Warm Vehicle Driveability Evaluation Procedure. Recorded demerits were first weighted as applicable to the vehicle operating mode. A sum of weighted demerits was then developed to represent overall adverse driving characteristics.

Performance data were measured as part of the driveability evaluation. Elapsed time (ET) data were obtained during wide-open throttle (WOT) accelerations from 0 to 70 miles per hour. WOT accelerations were performed in two sets with one set comprising two WOT ET's measured in one direction. WOT ET's were performed from each of two opposing directions to cancel affects introduced by wind and grade variations. Performance data are reported as a single average elapsed time for a WOT acceleration from 0 to 70 mph.

Engine braking characteristics were also evaluated as part of the driveability evaluation procedure. Elapsed times were measured from 70 to 30 miles per hour during closed throttle operation. Two sets of data were developed, one set from each of two opposing directions. Closed throttle deceleration ET's are reported as a single average elapsed time from 70 to 30 mph.

5. TECHNICAL DISCUSSION - PART II

Part I of the technical discussion covered overall program objectives and the criteria of design. It also described specifications and procurement efforts with respect to the primary sample of vehicles. In addition it outlined the testing procedures, laboratory facilities and equipment and general data handling and processing procedures employed in the conduct of the study.

Part II of the technical discussion follows. It describes in greater detail the various vehicle sub-samples, and control strategies and outlines the various testing and evaluation techniques applied.

5.1 EVALUATION OF EMISSION CONTROL STRATEGIES

Four emission control strategies were to be considered; idle emissions inspection; exhaust control retrofit comprising two elements, California approved and high altitude kits; modified tuning specifications and; mandatory engine maintenance. By design, a sample of 1964-1973 model-year vehicles was to be employed to evaluate each control strategy. Before the evaluations could proceed however, several subordinate tasks were to be accomplished.

5.1.1 Idle Emission Inspection

A 300 vehicle sample representing the various makes, model-years, engine sizes and other significant parameters of the 1964-1973 model-year population was considered adequate to evaluate idle emission inspection. In the absence of applicable data, a prerequisite to this phase of the study was to establish idle emission pass/fail limits. Also, because of the heretofore untried approach to emission control in the test area, a sample of state licensed inspection stations was required to test the effectiveness of the strategy and to develop associated costs. Because of the wide and varied backgound of inspection and repair personnel, specific training was required in advance of actual evaluation. Finally, a testing and evaluation sequence was required to indicate the effectiveness of the inspection effort.

5.1.1.1 Pass/Fail Limits

In the design of the study an emission standard which would fail about 50 percent of the population was stipulated. In concept, this falure rate would permit an assessment of the effectiveness and costs of any failure rate of 50 percent or less. Because two populations were represented in the sample, 1968 and newer model-year vehicles with factory installed exhaust control systems and pre-1968 model-year vehicles without factory control systems, two failure limits were required.

To develop data from which emission failure limits could be determined, arrangements were made at the local level to utilize two national oil company service stations. These facilities were procured for the purpose of conducting a "parking lot survey" of emissions levels. The oil company agreed to provide facilities, electrical power to power test instrumentation, and access to its customers. The survey was scheduled for completion in a period of three days and was designed to sample about 300 automobiles.

During the interval the survey was scheduled, the Denver area was experiencing a gasoline shortage. As a result, a majority of stations were scheduling gasoline sales starting about 7:00 A.M. and continuing until 50 percent of the daily fuel quota was sold, normally until about 10:30 to 11:00 A.M. Sales would then be terminated for a period of time. At about 2:00 P.M. sales would again continue until the daily fuel quota was sold for that day. During the time period when fuel was available, customers were normally routed in a one-way fashion through the station. Nearly all customers seeking fuel would pass a given point. With the cooperation of service station management and personnel, exhaust analyzers and ATL personnel were stationed at critical points. Gasoline customers passing these points were invited to participate in the survey. An affirmative reply was the normal response and a relatively large number of inspections were performed.

Sun Electric Company, Model EPA-75 hydrocarbon and carbon monoxide analyzers were used to survey emission levels. Emissions at curb idle and at 2500 rpm, no-load, were recorded along with vehicle identification data.

In all, 441 vehicles were surveyed. Of these, 27 vehicles were considered to be outside the area of interest (1963 and older vehicles). The remaining 414 vehicles were distributed as follows:

1968-1973	335 Vehicles
1964-1967	79 Vehicles

Admittedly, this distribution is not representative* of the overall vehicle population. However, representation of respective samples was considered adequate to define failure limits.

In considering failure limits with regard to both a carbon monoxide and hydrocarbon emission standard, it should be recognized that an infinite variety of combinations can be selected. For the subject study, however, the Colorado Health Department required failure limits for both CO and HC which would fail an equal number of vehicles respectively. These limits were found by varying the failure limits for HC and CO independently. Values were then selected at which failures caused by HC equalled the number of failures caused by CO and the total number of failures comprised 50 percent of the sample. Table 8 shows the hydrocarbon and carbon monoxide limits established from parking lot survey data. These data were utilized by selected safety inspection stations as pass/fail criteria for idle emission inspection.

Vehicle Population	HC	CO
1964-1967	800ppm	6.0%
1968-1973	330ppm	4.0%

Table 8. HC and CO Idle Limits at 50% Rejection Rate

5.1.1.2 Station Selection

Ten stations were selected to represent state licensed vehicle safety inspection stations. Since safety inspections are performed by several segments of the automobile repair industry, it was desirable that each segment be represented.

Sun Electric Company, through its local sales program, demonstrates an intimate knowledge of the local repair industry. As a result Sun was contacted and agreed to supply a list of candidate stations. From the list furnished by Sun, nine candidate stations were contacted. Details of the project were presented and station participation was solicited. One of the stations declined. Eight stations accepted and were joined by two additional stations initially contacted by ATL. All stations selected were located in the Aurora and east

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*The sample was probably biased toward newer models owned by a predominantly middle class station clientele.

Denver area, the same area from which the primary car sample was obtained. Figure 6. shows the distribution of selected stations by nature or class of business*.

Quantity	Classification
5 ea	Service Stations
3 ea	Independent Garages
2 ea	New Car Dealerships

Figure 6. Classification of Ten Selected Safety Inspection Stations

5.1.1.3 Personnel Training

In order to impart a level of standardization of idle emission inspection and resulting maintenance, training was provided. Training was comprised of two phases, classroom and on-site.

Station personnel were divided into two groups, inspectors and repair personnel. In this regard, it should be noted that in many cases a classification of personnel was purely arbitrary. Two classroom sessions were provided at the Sun Electric Company Training Center. Each lasted about 4 hours.

The first session, attended by inspectors and repair personnel, included about one hour of program orientation during which the objectives and purpose of the program were presented. The next hour was devoted to the concept of idle emissions inspection and included a run-through of idle inspection, adjustment, and maintenance procedures (Appendix 3) to be applied in the program. An introduction to the Sun EPA-75 HC-CO instrument was then presented. The introduction lasted about one-half of an hour. Finally, the session was concluded with about one and one-half hours of "hands-on" instrument experience and demonstrations of various engine malfunctions using an engine mock-up. Prior to dismissal, each inspector/mechanic team was required to perform an inspection of a vehicle used to provide transportation to the session. The second session, attended by repair personnel, was comprised of a more detailed course on engine adjustment and repair procedures.

The second phase consisted of on-site or on-the-job training and was provided on a limited basis as conditions warranted. To demonstrate:

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*Terms of participation do not allow participating stations to be further identified.

> A system was devised whereby station performance could be monitored. An element of the system included an evaluation of station performance whereby an inspection sheet, filled out by station personnel and returned to ATL with the test vehicle after inspection and maintenance, was closely scrutinized. Upon delivery of the next vehicle to the station in question, station personnel were made aware of any deviation from prescribed test, adjustment and maintenance procedures. These on-site training sessions were performed faithfully by laboratory personnel through the first five vehicles delivered to each station. Sessions were then discontinued except where gross deviations in procedures were noted.

A continuing review of station performance and personal interviews of station personnel, indicated the training provided was adequate insofar as station personnel were concerned.

5.1.1.4 Testing and Evaluation

Each of the 300 vehicles utilized to evaluate idle emission inspection was tested in the as-received condition, ie, the same condition in which the vehicle was found when delivered by the owner. Following initial vehicle check-out and acceptance procedures, the vehicle was allowed to temperature soak a minimum of 12 hours.

Following the soak interval Federal exhaust emission tests, key mode emission tests and laboratory idle emission inspections were performed. The vehicle was then moved to a staging area where the maintenance status of the vehicle was determined (Figure 7.). Idle rpm, ignition timing and dwell were measured and compared to manufacturers specifications (MS). Departure from

1. Points/Condenser ok? YES NO
2. Distributer cap ok? YES NO
3. Ignition wires ok? YES NO
4. Air Pump ok? NA YES NO
5. Idle RPM ______ - (MS) ______ = ______
6. Timing Degrees ______ - (MS) ______ = ______
7. Dwell ______ - (MS) ______ = ______
8. PCV ok? NA YES NO
9. Air Cleaner ok? YES NO
10. Choke ok? (Vacuum kick & heat riser) NA YES NO
11. Idle CO MS ______ ______
12. Misfire? YES NO
13. NO_x Control ok? NA YES NO

Figure 7. Determination of Maintenance Status

manufacturers specifications was then determined and the difference was reported. With the exception of idle CO, all other parameters of interest were inspected visually or subjected to a performance check where applicable. Performance and diagnostic procedures employed are shown in Figure 8. Upon completion of initial emission tests and engine and component diagnostics, vehicles were transferred to inspection stations for idle emission inspection.

1. Air Pump - With the engine running, the air pump hose is pulled off. If air is flowing, the pump is assumed to be working. With the engine off, the belt tension is checked for sufficient tension to drive the pump at high speed.
2. Idle RPM and dwell will be measured with a Sun Electric Company Tach-Dwell Meter.
3. Timing will be measured with a Sun timing light.
4. The PCV system test procedure is as follows:
   Remove PCV valve from valve cover, note RPM. Cover valve inlet, again note RPM. If the system is working properly the RPM should fall off at least 50 RPM when the inlet is covered.
5. The air cleaner is assumed to be OK if it is not oil soaked or excessively dusty.
6. The choke is assumed to be OK if the heat riser is not bent and is operating freely, and if the vacuum kick responds to vacuum and is operating freely.
7. The idle CO will be measured with a Beckman Model 315A NDIR CO analyzer, during key mode idle.
8. Misfire will be noted by monitoring HC as the car is accelerated to key mode low cruise and again as the car is accelerated to key mode high cruise.
9. NO_x Control - The distributer vacuum advance will be examined at key mode low cruise and at key mode high cruise. At low cruise there should be no vacuum, at high cruise there should be vacuum to the distributor.

Figure 8. Engine and Component Diagnostic Procedures

Stations were assigned code numbers (1 through 10) and test cars were normally transferred to stations on a pre-determined rotational basis, ie, car #1 to station #1, car #2 to station #2 . . . car #11 to station #1. In actual practice, however, the rotational system could not be maintained. Several stations were reluctant or refused to service certain cars, eg, a dealership would accept only those makes sold by the dealership; other stations would not service foreign made vehicles. In any event, each station received and inspected one-tenth of the sample or about 30 cars.

At the inspection station, idle emission inspections were performed independently and without knowledge of laboratory inspection results. As part of the inspection procedure (Appendix 3) an Inspection Station Results form (Appendix 2) was utilized. The data form provided data blocks in which inspection results were to be recorded and on which in-use instrument ranges were to be reported. The inspector was also required to indicate a "pass" or "fail" based on a comparison of measured emission levels as a function of vehicle model-year (1964-1967 and 1968 & newer), versus pre-determined emission standards (Table 6). Vehicles designated by the inspector as "passed" were transferred back to the laboratory without regard to laboratory inspection data. No adjustments or maintenance were performed by station personnel. Vehicles "failed" by inspectors were transferred to station repair personnel for corrective action.

The garage idle emission inspection, and subsequent adjustment and repair procedures were designed to regulate the sequence of adjustment and repair and thereby hold guess-work to a minimum. The procedures require that several relatively simple yet effective adjustments be performed in sequence. If these adjustments fail to produce the desired results, more extensive maintenance is allowed. The inspection, adjustment, and repair sequence is prescribed to be performed in the following manner:

1. Inspect HC and CO at curb idle and at 2500 rpm, no load.
2. If vehicle passes, stop. If vehicle fails HC, CO or both, check curb idle rpm. Adjust if out of specifications. Measure HC and CO. If vehicle passes, stop.
3. If vehicle failed CO, adjust carburetor idle mixture screw to leaner air/fuel mixture setting. Re-adjust curb idle rpm as required. If vehicle passes, stop.

4. If vehicle failed HC, check ignition timing. Adjust if out of specifications. If vehicle passes, stop.

5. A list of probable cause for high emission levels is provided as an aid in diagnosing causes for failure. Only those repairs necessary to bring idle HC and CO into compliance are permitted.

Maintenance and inspection cost controls were established for the project. A per vehicle cost limit was established at $50 for combined inspection and repair charges. Garages were instructed to contact the laboratory when costs in excess of the limit were anticipated. In a situation such as this, a decision to repair or not to repair was made against the backgound of the magnitude of repair required. Repairs to bring the vehicle into compliance were normally authorized if in the range of $50 to $100. If, because of excessive costs, repairs were not authorized, the vehicle was returned to the laboratory. In this situation station personnel were instructed to prepare an estimate of charges to bring the vehicle into compliance. Aside from the recommended inspection, adjustment, and repair procedures and the $50 cost limitation, no other constraints were applied. Station personnel were instructed and encouraged to charge the program consistent with the respective practices of each facility.

Passed vehicles were returned to the laboratory without regard for inspection results or actual engine condition (eg; a passed vehicle may have obviously required an idle adjustment as evidenced by rough idling characteristics; the adjustment was not performed since emission levels were below standards). Vehicles which failed initial inspections and required maintenance were presumably adjusted and maintained in accordance with the best judgement of repair personnel. Vehicles which failed initial inspection were maintained and re-inspected until acceptable emission levels were attained, then returned to the laboratory for re-test.

At the laboratory, vehicles were temperature soaked for the prescribed interval and another series of emission tests were performed. The idle emission inspection phase was thereby complete.

5.1.2 Exhaust Control Retrofit - California Approved

Several generic types of exhaust control retrofit systems were scheduled for evaluation. Selection of specific types was determined in consultation with the Colorado Health Department and the various contractors involved in the study. A sub-sample of 50 vehicles was to be utilized to evaluate selected retrofits. Testing and evaluation procedures were applied with respect to emissions, driveability, performance and fuel economy.

5.1.2.1 Vehicle Selection

A total of 50 vehicles were selected from the idle inspection sample and were prepared and tested after idle emissions inspections were completed. Vehicles were selected on the basis of appearance in the overall population with respect to model-year, make and engine size. These criteria dictated that the more popular vehicles be represented. On this basis, the sample shown in Table 9. was selected.

Make	No. of Vehicles Selected by Model-Year										
	73	72	71	70	69	68	67	66	65	64	Total
Ammo	0	0	0	0	0	0	0	0	0	0	0
Buic	0	0	0	0	0	0	0	0	0	0	0
Cadi	0	0	0	0	0	0	0	0	0	0	0
Chev	0	1	1	1	2	1	1	1	1	1	10
Chry	0	0	0	0	0	0	0	0	0	0	0
Dodg	1	1	1	0	0	0	0	1	1	0	5
Ford	0	3	2	2	1	1	2	1	1	2	15
Impe	0	0	0	0	0	0	0	0	0	0	0
Linc	0	0	0	0	0	0	0	0	0	0	0
Merc	0	0	0	0	0	0	0	0	0	0	0
Olds	0	0	0	0	1	0	0	1	0	1	3
Plym	0	1	1	0	1	1	1	1	1	0	7
Pont	0	0	0	0	1	1	1	1	1	0	5
Volk	0	0	1	1	0	0	0	0	0	0	2
Total	1	6	6	4	6	4	5	6	5	4	*47

Table 9. Sea-Leval Retrofit Sample

1973 model-year vehicles were not originally scheduled for retrofit evaluation. However, a single 1973 model-year vehicle was accepted since it was one of a few available vehicles outfitted for liquified petroleum gas (LPG) operation. Arrangements to equip 3 vehicles were provided solely to comply with project requirements. Efforts to locally procure 3 natural gas (NG) fueled vehicles which were also part of original requirements, proved to be fruitless.

5.1.2.2 Retrofit Description and Procurement

Specific types of retrofit were to be considered. They are as described below and were designated for evaluation on factory installed emission control

*Total is 3 vehicles short of 50. 3 vehicles were originally scheduled for natural gas fuel evaluation. NG systems were not available.

cars and uncontrolled cars as shown in Table 10. Detailed retrofit sub-samples are presented in Appendix 6.

Model-Years	Sample Size	Description
1968 through 1972	4 ea	Catalytic Converter
	3 ea	LPG Fuel System
	3 ea	NG Fuel System
	5 ea	Air Bleed
	5 ea	Float Bowl Pressure Regulation
	4 ea	Air Bleed - EGR
	5 ea	EGR
1964 through 1967	6 ea	Air Bleed - VSAD
	7 ea	Air Bleed - EGR
	8 ea	EGR - VSAD

Table 10. Retrofit Types and Sample Size

Each of the described retrofits shown in Table 10. can be considered to comprise five types. They are described as follows:

> Catalytic converters and LPG and NG fuel systems although functionally different are considered as one class of retrofit, primarily because they are the more effective and costly types. Catalytic converters are normally oxidizing and, at Colorado altitudes, require secondary air to sustain the oxidation reaction. An oxidation catalyst in itself has little affect on NO_x. LPG and NG fuel systems normally operate at lean air/fuel mixtures. As a result liquified gas fuel systems can achieve low levels of CO, HC and NO_x.
>
> Air bleed systems normally introduce secondary or bleed air to the induction system. They can be effective in reducing CO and HC but normally cause NO_x to increase. Float bowl pressure regulation does not utilize bleed air but produces roughly the same affects as air bleed. The desirable affect of bowl pressure regulation is to enlean the air/fuel mixture thereby reducing CO and HC emissions.
>
> Air bleed - EGR systems utilize secondary air bleed to the induction system thereby reducing CO and HC. Exhaust gas recirculation (EGR) tends to reduce NO_x by recirculating nearly inert exhaust gas back through the combustion process. An inert gas acts as a diluent and lowers peak combustion temperature. High combustion temperatures result in NO_x producing reactions.
>
> EGR of itself primarily limits NO_x formation as described above.
>
> Air bleed - VSAD systems utilize secondary air and either total or partial vacuum spark advance disconnect. Air bleed tends to reduce CO and HC. Vacuum spark advance disconnect (VSAD) or modified spark (MSA) result primarily in NO_x control although VSAD or MSA can achieve HC reduction.
>
> EGR - VSAD (MSA) systems as described individually, normally control NO_x and HC.

Retrofit systems were procured from several of the various manufacturers which, in most situations also provided representatives to install and adjust the respective system. Because of the requirements of the study, several of the retrofit manufacturers provided partial systems as opposed to the total retrofit system normally marketed. Terms of participation preclude manufacturer identification with regards to a specific type.

5.1.2.3 Testing and Evaluation

Vehicles utilized for retrofit evaluation were selected from the sample of vehicles used in the evaluation of idle emission inspection. Upon completion of all testing related to idle inspection, vehicles selected for retrofit subsamples were retained and prepared for further testing. Engine components and parts and engine functions were extensively inspected for indications of malfunction. Malfunctions were corrected, borderline parts were replaced as required and engines were adjusted to manufacturer's recommended specifications. Idle air/fuel mixtures were adjusted at manufacturer's recommended idle speed to an indicated exhaust value of 1 to 3 mole percent CO. Mixtures were adjusted to achieve best idling characteristics within the prescribed CO range. Vehicles were then released to manufacturer's representatives for retrofit installation.

Following retrofit installation and adjustment, vehicles were retired for the temperature soak. Mass emission tests were performed from a cold start. Key mode and idle emission tests were performed. Vehicles were then driveability and performance rated by the California Warm Vehicle Driveability Evaluation Procedure (Appendix 7). Retrofit systems were then removed by manufacturers representatives or by laboratory personnel as appropriate. Engines were again inspected to verify normal operation. Altered settings were re-set to specifications and vehicles were retired for temperature soak. Following the prescribed soak interval cold start mass emission tests were performed. Key mode and idle emissions tests followed. The evaluation sequence was concluded with a driveability and performance evaluation. Engine component sealing and identification procedures, in preparation for the 6 month emission test re-call (degradation study) were completed, and vehicles were scheduled for owner pick-up. This segment of retrofit evaluation was thereby completed.

5.1.3 Exhaust Control Retrofit - High Altitude Kits

To evaluate the high altitude kits, a 100 vehicle sub-sample was chosen from the primary idle inspection sample. Kits and recommended installation procedures and adjustment specifications were procured from automobile manufacturers. Foreign-made vehicles were not scheduled for evaluation. Testing procedures were selected and a testing sequence was designed and executed in a manner consistent with overall program objectives.

5.1.3.1 Vehicle Selection

Since only the major domestic automobiles were to be evaluated, the vehicle sample was comprised of light-duty vehicles manufactured by American Motors Corporation (AMMO), Chrysler Corporation (CHRY), General Motors Corporation (GMC), and Ford Motor Company (FORD). Sample vehicles were selected to represent vehicles of high and moderate sales volume. Table 11 shows sample distribution by model-year and make. (A more detailed distribution is presented in Appendix 8).

Make	Mfgr.	No. of Vehicles Selected by Model-Year						
		73	72	71	70	69	68	Total
Ammo	AMMO	1	1	1	0	1	0	4
Buic	GMC	1	1	1	1	1	1	6
Cadi	GMC	0	1	0	0	0	1	2
Chev	GMC	5	4	4	4	4	5	26
Chry	CHRY	0	0	0	0	1	0	1
Dodg	CHRY	1	1	1	1	1	1	6
Ford	FORD	5	5	5	5	4	3	27
Impe	CHRY	0	0	0	0	0	0	0
Linc	FORD	0	0	0	0	0	0	0
Merc	FORD	1	1	1	1	1	1	6
Olds	GMC	1	1	1	1	1	1	6
Plym	CHRY	2	1	2	1	1	1	8
Pont	GMC	1	1	1	1	2	2	8
Total		18	17	17	15	17	16	100

Table 11. High Altitude Retrofit Vehicle Sample

5.1.3.2 Retrofit Description and Procurement

As indicated by Table 11, high altitude kits were to be evaluated on 1968 through 1973 model-year vehicles only. Each of the various domestic car manufacturers was contacted and the details of the project were presented. Component parts to comprise the various kits and recommended engine adjustment specifications were solicited. Each of the manufacturers responded and requirements were fulfilled.

High altitude kits were comprised of various carburetor and distributor parts and were accompanied by an application list. In some instances an idle adjustment procedure was specified. Each of the various kits supplied are described as follows:

American Motors Corporation

Lean main fuel metering jets

5 degree advance in basic ignition timing

Idle adjustment procedure not prescribed. Idle adjustment performed as generally recommended.

Chrysler Corporation

10% lean main fuel metering jets

Mixture enrichment staging springs which function at a vacuum 2 inches Hg less than standard (net result - leaner power enrichment).

5 degree advance in basic ignition timing.

Idle adjustment procedure not prescribed. Idle adjustment performed as generally recommended.

Limitations - parts supplied are applicable to Carter carburetors only. Holley equipped cars are recommended for complete carburetor replacement. Replacement carburetors were not supplied.

Ford Motor Company

Model Year	Choke	Basic Timing (degrees)	Power Valve (Inches Hg)	Jets
1968	-	+4	4.5 2v	2 lean
1969	-	+4	4.5 2v	-
1970	Link 2v	+4	4.5 2v	-
1971	Link 2v	+4	4.5 2v	-
1972	Link 2v	+4	4.5 2v	-
1973	Link 2v	+4	4.5 2v	-

Lean main metering fuel jets for 1968 models.

Lean Power valve assemblies for all 2v carburetors.

4° advance in basic ignition timing for all models.

Link provided with altitude notch to reduce (enlean) choke angle setting for 1970-1973 2v equipped models.

Idle adjustment procedure prescribed for all models.

General Motors Corporation

Distributor vacuum advance mechanism calibrated to operate 5 inches Hg less than standard resulting in ignition timing advance at lower engine load.

Lean power enrichment springs and assemblies.

Idle adjustment procedure not prescribed. Idle adjustment performed as generally recommended.

Kit installation and adjustment procedures were generally performed as indicated above. In several instances, parts supplied by one manufacturer were utilized to equip vehicles of another manufacturer as applicable, eg, an

American Motors vehicle, equipped with an Autolite or Motorcraft (Ford) carburetor was equipped with a Ford kit. In other instances where a specific component of the kit did not apply to a given situation, the component was not utilized for replacement. In this respect it should be noted that a general approach to high altitude retrofit was applied. Individual parts supplied were not necessarily tailored to this application in particualr but were assembled and provided as off-the-shelf items.

5.1.3.3 Testing and Evaluation

The high altitude kit sub-sample was derived from the sample of vehicles utilized for idle emission inspection. After completing tests related to idle inspection, test vehicles were subjected to diagnosis, worn or damaged engine parts were replaced and high altitude kits were installed. Installations were performed by laboratory personnel in accordance with directions supplied by the respective manufacturers. Engine adjustments were then checked and where applicable, kit adjustment specifications were applied.

After kit installation, vehicles were temperature soaked; mass, key mode and idle emission tests were performed and warm driveability evaluations were completed. Kit hardware was then removed, original parts were replaced and adjustments were re-set to factory specifications. Emissions and driveability evaluations were completed at factory standard configurations and engine component and adjustment items were sealed and identified for 6 month recall tests. High altitude retrofit evaluation was thereby completed.

5.1.4 Modified Tuning Specifications

Twenty-five vehicles were selected to be utilized to evaluate modified tuning specifications. An experimental procedure was devised whereby the more significant emission related variables were evaluated. Testing procedures were chosen and flow charts were established to facilitate test vehicle routing through the various routines assigned.

5.1.4.1 Vehicle Selection

Twenty five vehicles were selected from the primary sample. Selection was such as to achieve representation of the various vehicle model-years and the more popular makes registered. Table 12 shows the sub-sample selected to perform the evaluation of modified tuning specifications by make and model-year.

Make	No. of Vehicles by Model-Year										
	73	72	71	70	69	68	67	66	65	64	Total
Chev	1	1	1	1	1	1	1	1	1	1	10
Ford	1	1	1	1	1	1	1	1	1	1	10
Pont	0	0	0	0	0	1	0	1	0	0	2
Volk	1	0	1	0	1	0	0	0	0	0	3
Total	3	2	3	2	3	3	2	3	2	2	25

Table 12. Modified Tuning Specifications Vehicle Sample

5.4.1.2 Description of Specifications

Four significant emission related engine variables were selected for evaluation on each of 25 cars.

Vacuum choke kick

Basic ignition timing

Idle air/fuel mixture

Idle speed (rpm).

Each variable was assigned an experimental value which would presumeably work to improve combustion efficiency during cold and warm engine operation. Settings were established at what was presumed to be the maximum allowable limit without incurring severe driveability penalties. Experimental values are described as follows:

Vacuum choke kick

Set leaner than specifications at 1.5 x pull-off specified by manufacturer.

Basic ignition timing

Advanced from specified timing by 8 degrees.

Idle air/fuel mixture

Set leaner than specifications. Enleanment expressed in terms of drop in idle speed of 200 rpm. 200 rpm drop due to enleanment was recovered by increasing the throttle blade opening (idle speed screw).

Idle speed

Set higher than specified. Speed initially set as recommended by manufacturer in specified gear (drive or neutral). Shift selector then moved to neutral gear (if automatic transmission) and idle speed adjusted to achieve additional 200 rpm.

A certain amount of interaction exists between certain of the variables. An advance in ignition timing, for example, causes an increase in engine rpm. By taking this interaction into account an adjustment sequence was designed as follows:

1. Vacuum choke kick (choke plate pull-off after cold engine start) is independent of other variables. It was adjusted firstly.
2. Basic timing was adjusted secondly at recommended engine rpm. Where the experimental adjustment procedure called for high idle rpm, basic ignition timing was not readjusted regardless of change caused by higher idle rpm.
3. Thirdly, idle air/fuel mixture was adjusted as described above.
4. Finally, idle speed was adjusted as described above.

Eight each tests were scheduled for each test vehicle. Prior to testing each of the vehicles were set to the combinations shown in Table 13, where:

a = Choke to specs
Timing to specs
Idle A/F to experimental value
Idle rpm to experimental value

b = Choke to experimental value
Timing to specs
Idle A/F to specs
Idle rpm to experimental value

c = Choke to specs
Timing to experimental value
Idle A/F to experimental value
Idle rpm to specs

d = Choke to experimental value
Timing to specs
Idle A/F to experimental value
Idle rpm to specs

e = Choke to specs
Timing to experimental value
Idle A/F to specs
Idle rpm to experimental value

f = Choke to experimental value
Timing to experimental value
Idle A/F to specs
Idle rpm to specs

g = Choke to experimental value
Timing to experimental value
Idle A/F to experimental value
Idle rpm to experimental value

The final test on each vehicle, s, was performed with each of the variables set to manufacturer's specifications.

To perform the experiment, a random order of adjustment was applied to evaluate the variables singularly and in combination as shown in Table 13.

Car No.	Coded Adjustment Procedure Test Number							
	1	2	3	4	5	6	7	8
1	a	b	c	d	e	f	g	s
2	b	d	f	e	a	g	c	s
3	e	a	c	g	b	d	f	s
4	e	f	a	c	g	d	b	s
5	c	d	g	b	f	e	a	s
6	a	b	g	e	f	d	c	s
7	b	g	a	d	c	f	e	s
8	b	f	d	a	g	c	e	s
9	g	f	c	b	a	d	e	s
10	g	f	d	a	b	e	c	s
11	d	a	e	c	b	f	g	s
12	d	a	c	f	e	b	g	s
13	g	c	f	a	e	d	b	s
14	e	b	f	g	a	c	d	s
15	d	e	a	f	b	c	g	s
16	c	f	a	e	g	d	b	s
17	d	f	c	a	g	b	e	s
18	d	f	a	e	b	g	c	s
19	e	c	g	a	b	f	d	s
20	a	e	b	f	g	c	d	s
21	g	f	b	e	a	c	d	s
22	d	g	a	f	c	b	e	s
23	b	e	d	a	g	c	f	s
24	d	c	a	g	b	f	e	s
25	d	g	a	e	c	b	f	s

Table 13. Test Sequence Order for Modified Tuning Specifications Experiment

5.1.4.3 Testing and Evaluation

Vehicles used in the modified tuning specifications evaluation were selected from the idle inspection sample. Upon completion of idle inspection related tests, vehicles were diagnosed. Malfunctions were corrected. Engines were then set to specifications and de-tuned in accordance with the experimental adjustment procedure. Cold start mass emissions tests were performed and key mode and idle emissions tests were conducted. Driveability and performance evaluations were then completed. Engines were then tuned to experimental values and testing was repeated. The adjustment and testing sequence was repeated until each of the eight tests were complete. This phase of the program was then completed with engine component identification and sealing for emissions degredation and return of vehicles to owners.

5.1.5 Mandatory Engine Maintenance

In order to evaluate mandatory engine maintenance a sample of vehicles was selected from the primary sample. The method of selection is described below. Experimental mandatory engine maintenance requirements were then established and testing procedures were selected.

5.1.5.1 Sample Selection

Vehicles appearing in the retrofit (California approved and high altitude kits) and modified tuning specifications sub-samples were utilized to evaluate mandatory engine maintenance. 100 vehicles were used to evaluate altitude retrofit kits, 44 vehicles were used to evaluate California approved or sea-level retrofits, excluding gaseous conversion, and 25 vehicles were used to evaluate modified timing specifications for a total of 169 vehicles. However, 14 of the 169 vehicles were used for more than one task leaving a total of 155 vehicles in the mandatory engine maintenance sub-sample. Distribution of the 155 vehicle sub-sample by model-year and make is shown in Table 14.

Make	No. of Vehicles by Model-Year										
	73	72	71	70	69	68	67	66	65	64	Total
Ammo	1	1	1	0	1	0	0	0	0	0	4
Buic	1	1	1	1	1	1	0	0	0	0	6
Cadi	0	1	0	0	0	1	0	0	0	0	2
Chev	6	5	5	6	6	6	2	2	2	2	42
Chry	0	0	0	0	1	0	0	0	0	0	1
Dodg	2	2	1	1	1	1	0	1	1	0	10
Ford	5	8	7	6	5	5	3	2	2	3	46
Impe	0	0	0	0	0	0	0	0	0	0	0
Linc	0	0	0	0	0	0	0	0	0	0	0
Merc	1	1	1	1	1	1	0	0	0	0	6
Olds	1	1	1	1	1	1	1	1	0	1	9
Plym	2	2	3	0	2	2	1	1	1	0	14
Pont	1	1	1	1	3	2	1	2	1	0	13
Volk	1	0	2	1	1	0	0	0	0	0	5
Total	21	23	23	18	23	20	8	9	7	6	155

Table 14. Mandatory Engine Maintenance Vehicle Sample

5.1.5.2 Description of Maintenance

To evaluate the effectiveness of mandatory engine maintenance a quasi-theoretical approach was employed. The approach is based on the assumption that a change in emission related engine performance will not be affected by replacing a non-malfunctioning engine part with a new part. Based on this assumption, non-malfunctioning engine parts were not routinely replaced in favor of new parts.

As noted, vehicles used to evaluate mandatory maintenance were used initially to evaluate idle emission inspection. In this regard, all vehicles completing the idle inspection phase of the program, at the very least, were in sufficiently good condition to pass idle emission standards (except those vehicles which were not repaired due to excessive cost). However, the condition of an engine which passed idle inspection was not considered adequate to evaluate mandatory engine maintenance effectiveness and in many cases additional maintenance and adjustments were required.

As discussed, vehicles used to evaluate retrofits and tuning specifications were assigned to the mandatory maintenance sub-sample. Prior to utilizing any vehicle in retrofit or tuning specification sub-samples, each vehicle was subjected to extensive engine diagnosis and set to manufacturer's specifications. Parts which showed obvious malfunction and parts of questionable or borderline serviceability were replaced. Although diagnostic procedures were applied to the engine in general, particular emphasis was applied to certain engine parts and adjustments which, with regards to this aspect of investigation, constitute mandatory engine maintenance. Mandatory engine maintenance was thereby defined to comprise replacement of the following parts:

Spark plugs
Distributor contact points
Condensor
Air filter element

and adjustment of the following parameters:

Contact point dwell
Ignition timing
Idle Air/fuel mixture
Engine idle rpm.

To reiterate; for the experimental program, only those parts which by diagnosis indicated anywhere from borderline to total malfunction were actually replaced. The potential change attributed to the replacement of acceptable parts relating to emission performance was assumed to be minimal.

5.1.5.3 Testing and Evaluation

Upon completion of tests relating to idle emission inspection vehicles were subjected to extensive engine diagnosis. Parts were changed as applicable and engines were set to specifications. Retrofit kits were installed on respective vehicles, retrofit evaluations were performed, kits were removed and engines were re-tuned to specifications. Regarding the modified tuning specifications vehicle sample, vehicles were re-tuned, evaluated, re-tuned, evaluated, etc., until the tuning sequence was complete. Final tests were then performed on each vehicle. In each case final tests were performed with engines set to manufacturers specifications. Engine parts and adjustments were then identified and sealed as described and vehicles were returned to owners.

6. TECHNICAL DISCUSSION - PART III PROBLEM AREAS AND COSTS

In the course of investigation of the various control strategies, several problems became evident, particularly with respect to idle emissions inspection and high altitude kit installation. The following paragraphs discuss the highlights of the investigation with respect to each control strategy and define the problem areas. Summary cost data are also presented and discussed.

6.1 IDLE EMISSIONS INSPECTION

To review; 10 licensed safety inspection stations were selected, both class-room and on-site training was provided, and instrumentation was furnished and maintained. Beyond initial orientation and training, initial on-site training, and stand-by consultation services provided by laboratory personnel, inspection personnel operated more or less independently of laboratory supervision.

6.1.1 Preview of Inspection Facilities, Capabilities and Personnel

In order to determine the performance and capabilities status of the 10 selected stations with respect to the automotive repair industry at large, the services of a consultant were employed. The consultant, with over 30 years experience in nearly all aspects of automotive repair, demonstrates an intimate knowledge of the repair industry. The consultant was utilized to conduct personal inspections of participating garages and to interview station management and personnel. The general impressions of the consultant in this regard are as follows:

"The ten stations accurately represent a cross-section of the state-of-the-art ranging from a facility of general repair not offering tune-up service, to one of exclusively tune-up repair. The mechanics also ranged from no conception of tune-up concepts and practices to those who exhibited in-depth knowledge and skill in repair of carburetion and ignition problems. However, it did not follow that the better equipped shops or the more tune-up oriented ones, boasted the more skilled mechanic."

The following paragraphs should be considered against this background.

6.1.2 Personnel Training

The training provided to inspection station personnel was designed solely to cover only those aspects of inspection and maintenance which relate directly to the objectives of this study. The adequacy of training was unanimously expressed by garage management and personnel when surveyed and was further demonstrated by the fact that significant emission reductions were achieved (as will be shown in 7. Results). In this respect, however, it should be understood that:

1. There were only 10 stations involved in the study.
2. Classroom training sessions, although relatively short, were devoted solely to inspection procedures and the specifics and importance of proper engine adjustment.
3. Limited personalized on-site training was provided which was geared primarily to the detection and correction of technical and administrative problems.
4. Throughout the program laboratory personnel were on stand-by to consult on technical problems of special concern to station personnel.
5. Mention of the monitoring function of the laboratory was purposely avoided. However, garage personnel undoubtedly understood laboratory functions.

Although the adequacy of training was demonstrated, the training program, particularly that presented in the classroom, was at best minimal. Because of the program constraints, particularly with respect to the time allowed, training covered only the basics in instrument theory and operational procedures, and touched lightly on engine diagnostic procedures, adjustment and repair.

It was not within the scope of this study to develop an extensive inspection and mechanic training program. However, against the background provided by the study, the following elements of a training program are deemed desirable.

1. Background information should be provided on the motor vehicle as a source of air pollution to demonstrate the importance of the overall emission control program.
2. The general theory of engine operation and emission control functions should be stressed to provide the basis for understanding of diagnostic and repair procedures. The lack of knowledge in this regard was amply demonstrated by the questions raised and the discussions which followed during classroom training sessions provided by the program.
3. The fundamentals of engine and component diagnostics through utilization of the various diagnostic equipment available should be emphasized. A general lack of knowledge with respect to the application of diagnostic equipment was demonstrated during visits to the various garages.

4. The significance of proper engine repair and tune-up should be emphasized with both classroom and shop instruction provided. A detailed review of the first 50 cars, for example, indicated that 10 percent of the cars adjusted to reduce one pollutant were also mal-adjusted in such a way as to increase another pollutant.

6.1.3 Inspection and Repair Procedures

During both classroom sessions and on-site training visits, strict conformance to prescribed inspection and repair procedures was advocated. Although personnel at several of the stations expressed frustration with constraints of the garage inspection, adjustment and repair procedure, the systematic approach presented by the procedure presumeably proved to be a major factor in maintaining a reasonable cost effectiveness ratio (7. Results).

In the review and processing of inspection technical and cost data (Inspection Station Results form), several deficiencies with respect to the completeness of forms and other discrepencies in data were found. These are summarized in Table 15. With respect to Table 15, inspection data sheets indicating a "passed" vehicle where failing emission levels were actually recorded and sheets indicating a "failed" vehicle where passing emission levels were actually recorded are most commonly attributed to inspector error as to what allowable limits actually constitute a passed or failed vehicle (intentional or unintentional).

Description	No.	%
Forms improperly filled out or incomplete	199	66
Cars on which unnecessary adjustments were performed or adjustments were performed out of sequence	24	8
Cars which were marked "failed" but which inspector's own readings indicated a pass	39	13
Cars which were marked "passed" but which inspector's own readings indicated a failure	9	3

Table 15. Summary of Deficiencies and Discrepencies Found in Data Reported by Garages

6.1.4 Station Performance and Costs

Inspection stations were selected to represent various segments of the repair industry. For discussion purposes each station is assigned a code number which identifies it in connection with its primary activity, shown in Table 16.

Code Assigned	Type of Activity
SS-1	Service Station
D-2	New Car Dealership
D-3	New Car Dealership
IND-4	Independent Garage
IND-5	Independent Garage
SS-6	Service Station
IND-7	Independent Garage
SS-8	Service Station
SS-9	Service Station
SS-10	Service Station

Table 16. Inspection Station Identification

6.1.4.1 Station Pass/Fail Rates

Although the program was designed such that each station was to inspect 30 vehicles, for various reasons an equal distribution of vehicles was not achieved. The range in vehicles inspected per station was from 28 vehicles at a minimum to 31 vehicles at a maximum. Table 17 shows the total number of vehicles inspected by each station and pass/fail performance data. The code assignments presented in Table 16 apply.

Station Code	No. of Veh. Inspected	Vehicles Passed		Vehicles Failed					
				HC		CO		Both	
		No.	(%)	(No.)	(%)	(No.)	(%)	(No.)	(%)
SS-1	30	14	47	3	10	8	27	5	17
D-2	29	12	41	2	7	1	3	14	48
D-3	31	8	26	4	13	9	29	10	32
IND-4	30	14	47	1	3	4	13	11	37
IND-5	31	14	45	7	23	7	23	3	10
SS-6	31	12	39	5	16	6	19	8	26
IND-7	29	0	0	2	7	3	10	24	83
SS-8	30	12	40	3	10	5	17	10	33
SS-9	28	20	71	1	4	0	0	7	25
SS-10	31	19	61	5	16	3	10	4	13
STA.AVG.	30	12.5	41.7	3.3	10.9	4.6	15.1	9.6	32.4

Table 17. Inspection Pass/Fail Data by Station

As shown in Table 17, the average passing rate for the total sample is about 42 percent with a range from 0 percent passed to 71 percent passed. Average failure is shown at 11 percent for HC with a range from 3 percent to 23 percent. Average CO failure is shown at 15.2 percent with a range from 0 percent to 29 percent. Average failure of vehicles for both HC and CO is 32.4 percent with a range of 10 percent to 83 percent. By combining average failure rates for HC, CO, and HC-CO together, an average failure rate of about 59 percent is obtained as compared to the design failure rate of 50 percent. The apparent disparity in the actual failure rate versus design failure rate is attributed primarily to the performance of two of the stations, D-3 and IND-7.

6.1.4.2 Station Inspection Charges

As indicated previously, each of the participating stations was encouraged to charge the project at rates consistent with practices normal to the garage respective of both inspection and maintenance charges. Table 18 shows the average inspection costs charged to the program by each station.

Station Code	No. of Vehicles Inspected	Inspection Costs	
		Total($)	Avg/Veh($)
SS-1	30	75.00	2.50
D-2	29	158.00	5.45
D-3	31	186.00	6.00
IND-4	30	150.00	5.00
IND-5	31	170.50	5.50
SS-6	31	139.50	4.50
IND-7	29	72.50	2.50
SS-8	30	105.00	3.50
SS-9	28	112.00	4.00
SS-10	31	46.50	1.50
STA.AVG.	30	121.50	4.05

Table 18. Summary of Inspection Charges

As shown in Table 18, the average inspection cost is $4.05 per vehicle with an average range by station from $1.50 per vehicle to $6.00 per vehicle. Estimates by laboratory personnel establish inspection labor to be in the range of 0.25 to 0.33 man-hours per vehicle. This estimate includes initial customer contact, performance of idle emissions inspection, completion of test forms (as utilized by the laboratory), and final customer contact. The time estimate assumes the vehicle exhaust system is intact, the engine is warm (a requirement of inspection procedures), and instrumentation is in a stand-by condition. At the labor rate of $12.00 per hour (assumed to be a typical hourly rate) the laboratory estimated inspection rate is in the range of $3.00 to $4.00 per inspection, which is consistent with the average rate of $4.05 per inspection charged to the program.

6.1.4.3 Station Maintenance Costs

A summary of adjustment and repair costs is shown in Table 19, where the average station cost for failed vehicles (Avg/Failed Veh.) ranges from $2.53 to $14.25 per vehicle and the average station cost for all vehicles inspected

(Avg. all Veh.) ranges from $0.76 to $12.26 per vehicle. The mean cost per failed vehicle is $10.57 and the mean cost per vehicle inspected is $6.14.

Station	Number of Cars		Maintenance Costs		
Code	Inspected	Maintained	Total($)	Avg/Failed Veh($)	Avg all Veh($)
SS-1	30	16	216.59	13.54	7.22
D-2	29	17	159.07	9.36	5.48
D-3	31	23	268.25	11.66	8.65
IND-4	30	16	40.50	2.53	1.35
IND-5	31	17	165.00	9.71	5.32
SS-6	31	19	265.91	14.00	8.58
IND-7	29	29	355.65	12.26	12.26
SS-8	30	18	187.25	10.40	6.24
SS-9	28	8	21.22	2.65	0.76
SS-10	31	12	170.95	14.25	5.51
STA.AVG.	30	17.5	185.04	10.57/Veh.	6.14/Veh.

Table 19. Summary of Maintenance/Costs by Station

6.1.4.4 Combined Station Costs

Table 20 shows a cost summary of combined inspection and maintenance costs.

Station	Number of Cars		Combined Costs	
Code	Inspected	Maintained	Total	Avg all Veh($)
SS-1	30	16	291.59	9.72
D-2	29	17	317.07	10.93
D-3	31	23	454.25	14.65
IND-4	30	16	190.50	6.35
IND-5	31	17	335.50	10.82
SS-6	31	19	405.41	13.08
IND-7	29	29	428.15	14.76
SS-8	30	18	292.25	9.74
SS-9	28	8	133.22	4.76
SS-10	31	12	217.45	7.01
STA.AVG.	30	17.5	306.54	10.18/Veh.

Table 20. Summary of Inspection and Maintenance Costs by Station

As shown, the average cost for both inspection and maintenance is $10.18 per vehicle. Costs shown reflect only those charges which were actually billed and are not inclusive of charges estimated to bring certain of the vehicles into compliance (those which failed inspection and were not repaired due to excessive costs to the program).

6.1.4.5 Estimate of Overcharge

As discussed in other sections, a request was made of station personnel to detail charges in connection with each phase of inspection, adjustment and repair. In addition, station personnel were requested to supply cost estimates with respect to those vehicles which could not be brought into compliance within the cost limitation. Cost data were transmitted to the laboratory via Inspection Station Results data sheets.

Upon receipt of garage data, a review of inspection, adjustment and repair data was performed. These data were then compared with data obtained as a result of an after-maintenance engine status inspection. This inspection was performed on all vehicles which were reported to have initially failed the garage inspection and were subjected to garage maintenance. The cost data developed from the comparison is presented in Table 21. As indicated, the total cost for repairs performed unnecessarily is $149.52 and the total cost for questionable repairs is $254.37 with a combined total of $403.89. These figures ($149.52 and $403.89) represent the range of overcharge with respect to direct costs (exclusive of repair estimates) actually charged to the program.

Station Code	No. of Cars Unnecessarily Repaired	Unnecessary Repair Cost ($)	No. of Cars Questionably Repaired	Questionable Repair Cost ($)
SS-1	0	-	2	39.69
D-2	0	-	0	-
D-3	3	16.00	2	35.77
IND-4	0	-	0	-
IND-5	0	-	2	90.92
SS-6	1	21.70	0	-
IND-7	10	104.95	1	27.50
SS-8	1	49.15	0	-
SS-9	1	5.37	0	-
SS-10	2	1.50	1	14.34
TOTAL	18	149.52	7	254.37
STA.AVG.	1.8	14.95	0.7	25.74

Table 21. Overcharge Estimated from Direct Program Charges

From data shown in Tables 20 and 21 a range in overcharge is estimated and is found to be:

> A minimum per vehicle average for 175 failed vehicles of 8% or $0.85 per vehicle.
>
> A maximum per vehicle average for 175 failed vehicles of 22% or $2.31 per vehicle.

where:

$10.57 = Average repair cost/failed vehicle.

$ 0.85 = $149.52 ÷ 175 vehicles failed.

$ 2.31 = $403.89 ÷ 175 vehicles failed.

Although 8% can be considered as a minimum overcharge, the maximum overcharge could possibly be in excess of the 22% shown.

Table 22 was constructed from estimated costs reported by the various garages to bring certain of the failed vehicles into compliance. The data shown in Table 22 applies to those vehicles which required repair in excess of the nominal $50 repair limit or those vehicles on which malfunctions causing failure could not be identified.

Station Code	Vehicle No.	Amount of Estimate($)	Type of Repair	Justified (?)
SS-1	1	*	*	?
	2	40	*	?
	3	200	VALVE JOB,CARB OHAUL	VALVE JOB
D-2	1	101	VALVE JOB	No
	2	200	VALVE JOB, MAJOR T.U.	No
	3	90	MAJOR T.U.	No
D-3	None	-	-	-
IND-4	1	*	*	?
IND-5	1	45	CARB OHAUL INTA.GSKTS.	No
SS-6	1	*	*	?
	2	*	*	?
	3	*	*	?
	4	30	*	?
	5	45	NEW CARB.	Yes
	6	*	*	?
	7	50	*	?
IND-7	1	35	*	?
	2	40	MINOR T.U.	Yes
SS-8	1	30	*	?
SS-9	1	150	VALVE JOB	Yes
SS-10	1	28	*	?

* NOT PROVIDED ? UNABLE TO DETERMINE

Table 22. Garage Repair Cost Estimates to Bring Problem Vehicle into Compliance

From cost data supplied, the average cost to bring problem vehicles into compliance is $77 per vehicle. This average is based on the 14 vehicles for which cost estimates are provided (station operators are reluctant to provide estimates). Assuming the average applies to all problem vehicles, the total estimated charges are $1540. Assuming further, that the ratio of total justified to total reported charges can be applied ($385 ÷ $1084 = 0.36) the total justified cost is $554 (0.36 x $1540 = $554) and the total unjustified cost is $986 ($1540 - $554 = $986) or an additional $5.63 per vehicle for the 175 vehicles which failed initial inspections.

Since there appears to be no reason to doubt the motives of garage personnel with respect to the estimates provided, it can be assumed that if allowed to proceed, costs would have been incurred. Assuming that 50% of the estimated costs were actually incurred, average per vehicle repair costs for the 175 failed vehicles would be increased by $2.82 per vehicle. Maximum estimated overcharge is now calculated to be:

> A maximum per vehicle average for 175 vehicles of 38% or $5.13 per vehicle.

where:

> $13.39 = adjusted average repair cost/failed vehicle ($10.57 + $2.82).
>
> $ 5.13 = prior estimate + latter estimate ($2.31 + $2.82).

In summary then, the estimated minimum overcharge is 8% or $0.85 per failed vehicle and the estimated maximum overcharge is 38% or $5.13 per failed vehicle.

6.1.5 Garage Inspection (Analytical) Instrumentation

As discussed in other sections garage-type emissions inspection instrumentation was supplied to each of the 10 garages. Instrumentation supplied to each station was of the same manufacturer and model, Sun Electric Company, EPA-75 HC/CO analyzers. Instrumentation was initially calibrated using n-hexane standard gaseous blends. In addition, instrument calibration curves were checked and reset to agree with gaseous standards at intervals of two to three weeks throughout the testing phase. Calibrations were presumeably checked by garage personnel in accordance with specified inspection procedures prior to the performance of emissions inspections on individual test cars.

Station monitoring strategy included a laboratory inspection of all vehicles prior to delivery to garages for inspection. Laboratory emissions inspections were performed using two analytical systems plumbed in parallel to the sample source, the vehicle tailpipe. A Sun EPA-75 HC-CO instrument comprised one analytical system and one Beckman 315A CO analyzer and one Beckman 315A HC analyzer comprised the other system. Calibration curves were established initially using gaseous standards which were applied commonly to both systems. Calibration set-points were established immediately prior to tests on individual vehicles. The Beckman analyzers are of laboratory quality and have long been considered a standard instrument applied in automotive exhaust gas analyses.

A total of 300 idle emission tests with parallel Beckman/Sun analyses were performed. Data from each system was recorded and retained for analyses. In addition, garage inspection data was recorded and retained for further analyses. Linear regression analyses were then performed to establish correlations with respect to certain of the data sets.

The regression analyses established correlation coefficients of 0.942 for Beckman CO versus Lab Sun CO data sets and 0.701 for Beckman HC versus Lab Sun HC data sets. Because of the care and control exercised with respect to the accumulation of these data, the coefficients obtained are probably the highest which can be achieved and are therefore considered the standard by which other data sets can be evaluated*.

Linear regression analyses were also performed to establish correlations between the Sun instrument utilized in the laboratory and each of the garage instruments. Results of these analyses are presented in Table 23.

Station Code	Idle Emission Data HC	Idle Emission Data CO	2500 Engine Rpm Data HC	2500 Engine Rpm Data CO
SS-1	0.43	0.76	0.83	0.72
D-2	0.41	0.83	0.37	0.88
D-3	0.59	0.48	0.26	0.59
IND-4	0.83	0.76	0.73	0.76
IND-5	0.68	0.81	0.79	0.87
SS-6	0.54	0.81	0.60	0.77
IND-7	0.49	0.71	0.43	0.26
SS-8	0.76	0.73	0.84	0.89
SS-9	0.64	0.84	0.69	0.74
SS-10	0.44	0.89	0.61	0.80

Table 23. Correlation Coefficients, Laboratory Inspection Data versus Garage Inspection Data

As may be inferred from the data shown in Table 23, substantial differences exist with respect to garage inspection data where the range in correlation coefficients is found to be:

HC at Idle	from 0.43 to 0.83
HC at 2500 rpm	from 0.26 to 0.84
CO at Idle	from 0.48 to 0.89
CO at 2500 rpm	from 0.26 to 0.89

Out of deference to Sun Electric Company it should be noted that the apparent disparity in garage instruments cannot be solely related to instrument performance. Although some instrument drift was noted during intervals between calibrations, drift appeared to be a function of aging (all garage instruments were

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*Coefficients shown are based on CO and HC measurments at idle *and* 2500 rpm. Coefficients would probably improve if analyses were performed individually. However, the Beckman HC instrument was not utilized for 2500 rpm analysis and data is not available.

supplied as new equipment) and drift was relatively uniform with respect to all instruments.

The range in correlation coefficients established by linear regression analyses of laboratory versus garage data can be attributed to several factors. Among these factors are engine variables, individual instrument response characteristics, and instrument operating environment. The greatest single factor, however, appears to be the care and handling of the instrument itself and the manner in which it is operated.

As noted in various paragraphs of Part III, problems were experienced with two of the ten stations, particularly as related to excessively high vehicle failure rates. As can be seen in Table 23, the stations with the highest failure rates, D-3 and IND-7, also demonstrate the poorest correlation coefficients with respect to inspection instrumentation provided. Since neither of the two instruments appeared to be out of line with other instruments during periodic calibration checks, it is concluded that the poorer correlations are attributed to poor operating practices.

6.1.6 Summary of Observations

1. In general, the stations selected represent a cross-section of the automotive repair industry.

2. With respect to program objectives, the training provided to station personnel was adequate. However, to provide a better understanding of emission control concepts, more extensive training is required.

3. Garage inspection procedures were adequate. However, several problems were experienced with station personnel with respect to attention to standards and the transmission of data.

4. Actual inspection failure rates were higher than design failure rates. The differences can be attributed to an abnormally high rate of failure at one station (IND-7 as shown in Table 17) which failed all vehicles tested. One other station (D-3) appears to borderline in this respect.

5. Inspection charges ranged from an average of $1.50 per inspection at one station to $6.00 per inspection with an overall average inspection charge of $4.05 per vehicle. The average charge is consistent with laboratory estimates.

6. The average station cost per failed vehicle ranges from $2.53 to $14.25 per vehicle with an overall average of $10.57 per failed vehicle.

   The average station cost for all vehicles inspected ranges from $0.76 to $12.26 per vehicle with an overall average of $6.14 per vehicle.

7. The average combined station cost (inspection and repair) per failed vehicle ranges from $4.76 to $14.76 per vehicle with an overall average of $10.18 per vehicle.

8. Overcharge is estimated to range from 8% to 22% for failed vehicles or 8% to 38% as determined from direct program charges and direct program charges plus estimates to bring problem vehicles into compliance. In terms of costs, the ranges are from $0.85 to $2.31 per failed vehicle and $0.85 to $4.66 per failed vehicle respectively.
9. Correlation coefficients developed for various data sets show relatively large differences in the quality of emissions inspections. In this respect, the performance of two stations (D-3 and IND-7) is of lower quality than the performance of the remaining stations.

6.2 EXHAUST CONTROL RETROFIT - CALIFORNIA APPROVED

Several classes of retrofit were evaluated. Systems were supplied by the various manufacturers. Installation and initial adjustment labor was also provided.

6.2.1 Installation

Based on observation of actual installation of the various systems, with the exception of the more costly retrofits, installations are performed relatively easily. Only a normal assortment of hand power tools and assorted wrenches, screwdrivers, etc., are required. Installation of the more costly systems, catalytic converters and L-P gas systems, are more complex as reflected in installation charges.

With respect to catalytic systems, installation on a vehicle already equipped with an air pump requires converter installation only. This can normally be accomplished in much the same manner that exhaust system mufflers are installed. Where an air pump is not already mounted on the engine, installation becomes more difficult and removal of the radiator and/or relocation of an existing air conditioning compressor may occasionally be required. It should be noted that these difficulties were not encountered during the course of this program. Catalytic systems also require the use of lead-free fuels.

L-P gas systems require the addition of a supplemental fuel tank specially designed to handle the higher vapor pressure of L-P gas. Carburetor replacement is also a requirement since L-P systems require special carburetion. It is also desirable, particularly with respect to V-8 engines, to remove the intake manifold and block the exhaust gas passage which normally supplies heat to vaporize fuel in the intake manifold during cold engine operation.

6.2.2 Application

The following information was obtained directly from the respective manufacturer with regards to application.

Catalytic Converters

Approximately 60% of the 1968-1970 model-year vehicles.

75% of the 1971 model-year vehicles.

Nearly 100% of the 1972-1975 vehicles.

These vehicles comprise nearly 68% of the light-duty vehicle population and can operate on 91 octane lead-free fuel. The manufacturer also reports that at the moment the only make of vehicle which is not recommended for retrofits is Volkswagen. However, Volkswagen systems will probably be available within one year.

L-P Gas Systems

While almost any gasoline engine can be converted to L-P gas with good results, from the standpoint of economics and/or fuel availability, the supplier feels it is feasible to convert only fleet vehicles or individually owned automobiles which are operated in excess of 25,000 miles per year.

Air Bleed

With the exception of a few vehicles, air bleed systems can be installed on nearly 100% of the light-duty vehicle population.

Float Bowl Pressure Regulation

With the exception of a few vehicles, float bowl pressure regulation systems can be installed on all light-duty vehicles.

Air Bleed/EGR

Applicable to all vehicles in the 1964-1972 range with a few exceptions (fuel injection, vehicles with more than one carburetor, custom built vehicles, etc.).

EGR

Applicable to all vehicles in the 1964-1972 range with exceptions as noted in Air bleed/EGR.

Air Bleed/VSAD (HSA)

Applicable to all 1964-1972 model-year vehicles except those without vacuum spark advance.

EGR/VSAD (HSA)

Applicable to all 1964-1972 model-year vehicles except those without vacuum spark advance.

6.2.3 Costs

Table 24 was developed from cost data submitted by exhaust control retrofit manufacturers. The costs shown for catalytic converters range from a low of $52, which applies to a 4 cylinder engine already equipped with an air pump, to a high of $155 for a V-8 installation requiring an air pump. Converter installation costs are based on retrofitting in excess of one-half million cars. It is assumed that costs submitted by other manufacturers are also based on a relatively large sales volume with the possible exception of L-P gas systems.

Retrofit Type	Average Installed Cost($)
Catalytic Converter	52-155.00
L-P Gas	650.00
Air Bleed	20.00
Bowl Pressure Regulation	24.10
Air Bleed/EGR	35-36.95
EGR	32.15
Air Bleed/VSAD	24.95
EGR/VSAD	25.00

Table 24. Cost of Installed Retrofit by Class

6.2.4 Summary of Observations

1. Retrofit systems are relatively easy to install except L-P gas systems and catalytic converter systems requiring air pump installations. The converter itself is easily installed.
2. The application of retrofit is broad. Nearly 100% of 1964-1972 model-year vehicles can be retrofitted with one or more systems. L-P gas retrofit is recommended particularly for fleet and vehicles which accumulate high mileage.
3. The range in costs of retrofit is wide with a minimum of $20 for air bleed devices to a maximum of about $650 for an L-P gas system.

6.3 EXHAUST CONTROL RETROFIT - HIGH ALTITUDE KITS

Altitude kit hardware was supplied by the various domestic car manufacturers. Hardware was installed and adjusted in accordance with recommended procedures by laboratory personnel.

6.3.1 Installation

As discussed in several preceeding paragraphs, high altitude kit installations were performed by laboratory personnel. In this respect no attempt was made to provide personnel installing kits with special working conditions and for the most part, installations were performed under what can be described as normal garage-type conditions. A log book was maintained as part of the installation procedure. In it records were maintained with respect to parts installed and labor required to perform the various tasks.

As noted, kit hardware was installed under normal garage-type conditions (ie, special lighting, tools, bench area, etc, were not provided). From time to time an observation of several of the installations was made (observations were made under pretense by the consultant described in 6.1.1). As a result, the following observations were recorded.

1. Assemblies to be modified were neither cleaned nor removed.
2. No new parts or gaskets were routinely replaced except those which comprised the kit itself. On occasion a part or gasket inadvertently damaged during the replacement operation was replaced.
3. Linkage, levers or settings disturbed for the necessary disassembly of the unit were not cross-checked against a parts application or specification list to verify that proper parts were currently installed.
4. No positive identification of the unit part was attempted.
5. Installers were not required by experience or training to qualify as "experts" in the carburetion and ignition fields.

A combination of the five factors suggests that the benefits of modification would largely be cancelled by the errors and oversights committed during the installation process.

Kits were removed before vehicles were returned to owners (removal was accomplished as suggested by certain of the manufacturers to eliminate conflicts relating to car warranties). As a result the potential for installation errors and oversights was doubled. In any event, owner complaints developed. Examination of problems relating to owner complaints revealed that dirt contamination inside choke assemblies, carburetors and distributors was present in sufficient quantities to disable certain mechanisms. Another source of complaints was attributed simply to normal wear and tear. Settings and adjustments which had become operationally borderline failed to function properly once disturbed.

6.3.2 Application

Application of high altitude kits with respect to the parts and specifications supplied appears to be quite extensive. The parts supplied by General Motors were intended for use on all 1968-1973 model-year vehicles with a few possible exceptions. The same is true of kits supplied by Ford and American Motors. Parts supplied by Chrysler Corporation, however, were limited in application to Chrysler products equipped with Carter 2bbl carburetors only.

As a result, additional test vehicle procurement efforts were required.

6.3.3 Costs

Table 25 was constructed from log book data. Parts are charged at retail list prices and labor is charged at a typical labor rate of $12.00 per hour.

Mfgr	Carb (bbl)	# of Veh	Labor Hours	Labor Cost($)	Parts Cost($)	Combined Unit Cost($)
AMMO	2	2	0.55	6.60	1.00	7.60
	4	2	0.50	6.00	1.70	7.70
CHRY	1	1	0.40	4.80	1.75	6.55
	2	14	0.64	7.63	1.62	9.25
FORD	1	6	0.45	5.40	0.31	5.71
	2	25	0.69	8.30	2.59	10.90
	4	2	0.45	5.40	0.93	6.32
GM	1	4	0.32	3.90	0.00	3.90
	2	25	0.78	9.36	4.28	13.64
	4	19	0.77	9.28	3.81	13.09

Table 25. Summary High Altitude Kit Parts and Labor Costs

The cost range for high altitude kits is from about $3.90 including parts and labor to about $13.64 including parts and labor and applies to the installation conditions described. As indicated, it is probable that kit installation under typical repair facility conditions would result in a relatively high incidence of errors and oversights which would lead to numerous owner complaints. Kits could possibly be installed by specialists provided with the proper working conditions and complement of replacement parts to replace damaged or worn parts. In this situation, however, installation and parts costs are expected to be considerably higher than costs shown.

6.3.4 Summary of Observations

1. High altitude kits are relatively easy to install. However, intrinsic problems are associated with installations performed under typical garage-type conditions.
2. High altitude kit application is broad although with respect to certain of the Chrysler Corporation models and certain of the other models, installation is not recommended except as a complete carburetor replacement.
3. Labor and parts costs are reasonable as applied to conditions described. The average cost range is from $3.90 to $13.64 as applied in the study. Costs are predicted to be much higher, however, if applied under more exacting conditions.

6.4 MODIFIED TUNING SPECIFICATIONS

An experiment was performed on 25 cars whereby certain of the more significant emission related parameters were evaluated. Adjustments were varied according to a random sequence to yield a total of 7 combinations of variables on each of the 25 cars. The experiment was performed through the exclusive use of laboratory personnel.

6.4.1 Adjustments

The adjustment procedure has been described in detail in other sections. There were no particular problems which developed as related to the adjustment procedure itself although vehicle operational problems relating to safety were experienced. Several of the experimental settings called for a neutral idle rpm increase of 200 rpm. The increased rpm adversely affects engine braking characteristics during closed throttle decelerations which results in increased wheel braking requirements during deceleration and idle operating modes. It should be noted, however, that experimental values were selected to represent an extreme in adjustment tolerance and were devised specifically to attempt to reduce CO emissions.

6.4.2 Application

Although the experiments were performed on a limited number of vehicle-engine combinations, there is no reason to believe that certain of the more effective adjustment combinations will not apply to nearly all of the 1964-1972 light-duty vehicle population.

6.4.3 Costs

A discussion of costs is not applicable.

6.4.4 Summary of Observations

1. Modified tuning adjustments are relatively easy to perform. However, idle rpm adjustment to the experimental value poses problems relating to safety.
2. Adjustments can be applied to virtually all light-duty vehicles.

6.5 MANDATORY ENGINE MAINTENANCE

A quasi-theoretical approach was employed to evaluate mandatory engine maintenance. Mandatory maintenance was defined as routine replacement of certain of the emission related engine and component parts. Resulting from extensive diagnosis, certain of these parts which were either defective due to normal wear and tear or in borderline condition were replaced. An evaluation was then performed to determine the effectiveness of mandatory maintenance based on the assumption that replacement of parts in proper operating condition would result in minimal additional emissions reduction.

6.5.1 Installation

Because of the approach which was employed to evaluate mandatory engine maintenance, parts were not changed as a matter of routine. However, there is no reason to expect that problems of any magnitude would develop as generally applied.

6.5.2 Application

Since maintenance is now performed as a matter of routine on all vehicles there is obviously no problem with respect to application.

6.5.3 Costs

In order to establish costs for mandatory engine maintenance a flat rate manual and retail parts list were consulted. Part costs are based on replacement of the following items which are designated to comprise mandatory engine maintenance:

Spark plugs
Contact points/condensor
Air filter element

Labor is based on the flat-rate time indicated in the manual to install the above parts and to perform the following adjustments which in essence comprise a minor tune-up:

Ignition dwell adjustment
Ignition timing adjustment
Idle air/fuel mixture adjustment
Idle speed adjustment

Summary cost data for mandatory engine tune-up are shown in Table 26.

As indicated in Table 26, the cost range for mandatory engine maintenance is from $33.35 for an 8 cylinder American Motors product to $58.77 for 8 cylinder Buicks and Cadillacs.

Make	# of Veh	# of Cyl.	Labor Hours	Labor Costs$	Parts Costs$	Combined Unit Costs$
Ammo	4	8	2.00	24.00	9.35	33.35
Buic	6	8	2.80	33.60	25.17	58.77
Cadi	2	8	2.80	33.60	25.17	58.77
Chev	5	6	1.90	22.80	19.41	42.21
Chev	36	8	2.80	33.60	23.97	57.57
Chry	1	8	1.90	22.80	21.31	44.11
Dodg	1	6	1.60	19.20	17.41	36.61
Dodg	8	8	1.90	22.80	21.31	44.11
Ford	8	6	1.60	19.20	18.55	37.95
Ford	37	8	1.80	21.60	22.87	44.47
Merc	6	8	1.80	21.60	23.52	45.12
Olds	8	8	2.80	33.60	24.13	57.73
Plym	1	6	1.60	19.20	17.41	36.61
Plym	14	8	1.90	22.80	21.35	44.15
Pont	13	8	2.80	33.60	23.77	57.37
Volk	5	4	2.00	24.00	10.55	34.55

Table 26. Summary Mandatory Engine Maintenance Costs

6.5.4 Summary of Observations

1. Since mandatory engine maintenance is comprised of the same elements as minor tune-ups currently being performed as a matter of routine, no unusual problems are anticipated.

2. For the same reasons discussed above, mandatory engine maintenance can be applied to all vehicles.

3. Costs range from about $33.35 (or lower) to about $58.77 per unit. The majority of vehicles are expected to fall within this range.

7. RESULTS

This section contains the results of the study in summary form in terms of both effectiveness and cost effectiveness. In this respect it should be noted that effectiveness data is based solely on the immediate affects that were measured as a result of strategies applied. Potential deterioration which can be expected to occur has not as yet been measured, although emissions degredation factors on unmodified engines is forthcoming. In a similar regard, cost data which was utilized to establish cost effectiveness ratios do not take into account any of the factors which may be applied to determine the possible long term effects.

7.1 IDLE EMISSIONS INSPECTION

The paragraphs which relate to idle emission inspection include effectiveness and cost effectiveness data with respect to emission reduction and fuel economy at 0, 20, 30, 40, 50 and 60 percent rejection rates. Since the effectiveness and cost effectiveness data is developed from data obtained at roughly a 60 percent rejection rate the data shown which corresponds to 60 percent rejection is acurate as presented. This is not to imply that data shown for other rejection rates are inaccurate.

In developing the tables an HC and CO idle emission standard was found which failed vehicles equally by HC and CO at the rejection rate in question. Once the standard was found, the group of vehicles which failed the new standard were rejected. A cost analyses was performed and a new cost basis (CB) was established as follows:

$$CB = \frac{\text{Inspection costs + maintenance costs}}{\text{number of vehicles rejected}}$$

where:

> Inspection costs are equal to inspection costs for all vehicles (300 vehicles x $4.05/vehicle).
>
> maintenance costs are equal to all maintenance costs to repair failed vehicles.
>
> number of vehicles rejected is equal to the number of vehicles rejected by the standard in question.

The new cost basis was then combined with the effectiveness data and cost effectiveness was established for the rejection rate in question.

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Since the average vehicle cost at 0% rejection is $4.05 per vehicle (the average inspection cost) and the average vehicle cost at 60% rejection is $10.22 per vehicle, the approximate incremental cost from 0 to 60% rejection is about $1.00/vehicle for each additional 10% rejection or one-sixth of the difference in average costs. Because the vehicles were not actually adjusted to comply with the idle standard in question but were actually adjusted to the standard which failed 60% of the vehicles, average maintenance costs at other than 60% rejection are somewhat higher than would be measured if vehicles were adjusted to the corresponding standard. However, in a similar regard emission reductions at rejection rates other than 60% are also higher since vehicles were adjusted to the more stringent 60% rejection standard. Cost effectiveness data obtained are therefore representative of cost effectiveness data which would have been developed if vehicles had actually been adjusted to the idle standard at corresponding rejection rates. Idle emissions standards which were found to fail the vehicle sample at various rejection rates are shown in Table 27.

REJECTION RATE	1964-1967 Model-Year		1968-1973 Model-Year	
	HC(ppm)	CO(%)	HC(ppm)	CO(%)
20	1500	8.7	760	7.6
30	1100	8.2	580	6.4
40	850	8.0	460	5.2
50	700	7.1	400	4.5

Table 27. Idle Emissions Standards at Various Rejection Rates

A presentation of effectiveness and cost effectiveness data for idle emissions inspection follows. Fuel economy data is also presented. Driveability and performance data were not generated for this element of the study.

7.1.1 Effectiveness Data

Table 28 shows the emissions and fuel economy data in grams per mile and mpg which were measured at the various rejection rates. As can be seen in the Table, HC, CO and NO_x emissions tend to decrease at each successively higher rejection rate and fuel economy tends to improve.

Table 29 shows the emissions and fuel economy data in terms of absolute emissions reductions and fuel economy improvement.

REJECTION RATE	GRAMS PER MILE			ECONOMY
	HC	CO	NO_x	MPG
0	7.98	110.3	2.59	14.53
20	7.37	106.5	2.59	14.61
30	7.14	104.2	2.57	14.66
40	7.08	102.8	2.56	14.70
50	6.96	101.1	2.56	14.75
60	6.92	100.2	2.55	14.77

Table 28. Absolute Emissions and MPG Data at Various Rejection Rates

REJECTION RATE	GRAMS PER MILE			ECONOMY
	HC	CO	NO_x	MPG
0	0	0	0	0
20	0.61	3.85	0.019	0.08
30	0.84	6.09	0.027	0.14
40	0.90	7.53	0.037	0.17
50	1.02	9.24	0.032	0.23
60	1.05	10.16	0.047	0.25

Table 29. Absolute Emissions Reduction and Fuel Economy Improvement at Various Rejection Rates

Table 30 shows emission reductions and fuel economy improvement in terms of percent at the various rejection rates.

REJECTION RATE	% REDUCTION			% IMPROVEMENT
	HC	CO	NO_x	ECONOMY
0	0	0	0	0
20	7.63	3.49	0.74	0.57
30	10.48	5.52	1.05	0.95
40	11.24	6.82	1.42	1.18
50	12.72	8.37	1.23	1.57
60	13.21	9.21	1.80	1.71

Table 30. Percent Emissions Reduction and Fuel Economy Improvement at Various Rejection Rates

As can be seen in the Tables above, HC, CO, and NO_x reductions become greater with each successively higher rejection rate and fuel economy tends to improve. An examination of emissions and fuel economy data by vehicle make, model-year, engine size, vehicle weight and the emission controlled and uncontrolled vehicle populations indicates that emission reductions and fuel economy improvements are similarly achieved for each successively higher rejection rate. In this regard it can be concluded that vehicle inspection, rejection and maintenance is effective with respect to all of the factors investigated.

7.1.2 Cost Effectiveness Data

Cost data, including both inspection and maintenance fees, were combined with emissions data and a cost effectiveness (CE) ratio was developed. The CE ratio expresses the cost effectiveness relationship in terms of emissions reduction/dollar actually spent (cost estimates to repair problem vehicles are not included). In order that cost effectiveness data may be conveniently presented in terms of whole numbers, CE data is expressed as milligrams/mile/dollar. Table 31 shows cost effectiveness data at the various rejection rates.

REJECTION RATE	MILLIGRAMS/MILE/DOLLAR		
	HC	CO	NO_x
0	0	0	0
20	84	533	2.6
30	104	754	3.4
40	101	849	4.2
50	105	951	3.3
60	103	994	4.6

Table 31. Summary of Cost Effectiveness at Various Rejection Rates

As indicated in Table 31, the CE ratio for HC rises sharply from 0 to 20 percent rejection and is relatively level from 30 through 60 percent rejection. The CE ratio for CO, however, rises sharply from 0 and continues to rise at a decreasing rate through 60 percent rejection. CE for NO emissions is similar to that shown for HC. An examination of CE data by make, model-year, engine size, weight and the emissions controlled and uncontrolled vehicle population (Appendix 11) indicates roughly the same trends. In this respect it can be concluded that cost effectiveness data applies equally to all of the factors investigated.

Table 32 is comprised of summary data showing emissions reduction in percent and cost effectiveness at the various rejection rates.

REJECTION RATE	HC		CO		NO_x	
	(CE)	(%)	(CE)	(%)	(CE)	(%)
0	0	0	0	0	0	0
20	84	7.6	533	3.4	2.6	0.7
30	104	10.5	754	5.5	3.4	1.1
40	101	11.2	849	6.8	4.2	1.4
50	105	12.7	951	8.4	3.3	1.2
60	103	13.2	994	9.2	4.6	1.8

Table 32. Summary of Combined Cost Effectiveness and Percent Emissions Reduction at Various Rejection Rates

Table 32 is particularly useful as demonstrated by the following example.

A reduction in CO emissions is required at say a 8.5 percent level. The 8.5 percent level is near the 50 percent rejection level. At the 50 percent rejection level:

1. The CE ratio for HC is at an optimum level.
2. The HC reduction can be predicted to be nearly 13%.
3. The CE ratio for CO is less than optimum but is reasonable nonetheless.
4. The CE ratio for NO_x is near optimum (A second degree best fit curve to the data would probably indicate CE for NO_x to be optimum near 50% rejection).
5. The NO_x reduction can be predicted to be about 1.25 percent.

7.2 EXHAUST CONTROL RETROFIT (CALIFORNIA APPROVED)

The following paragraphs which relate to the California approved retrofit systems include data on emissions reduction effectiveness, and cost effectiveness and fuel economy data. Driveability and performance data are also shown. Since changes in driveability characteristics are not normally presented in terms of percent, changes are shown as an absolute difference in demerit ratings. Performance data are based on percent changes in acceleration and deceleration time as initially measured in seconds. Acceleration data are related to engine power output and deceleration data are related to engine braking characteristics during closed throttle engine operation.

There are no standards to which warm driveability characteristics can be compared aside from an improvement or deterioration from one vehicle condition to another. However, an indication of demerit ratings by vehicle population has been developed from the data generated. In this respect it has been found that the average demerit rating for 1964-1967 model-year vehicles is 25 and the average demerit rating for 1968-1973 model-year vehicles is 10. Average demerit ratings were developed from the sample of vehicles utilized to evaluate sea-level and altitude retrofits at baseline conditions. Each of the vehicles in the sample had been well tuned prior to evaluation.

7.2.1 Effectiveness Data

Table 33 shows summary baseline emissions and fuel economy data for the various samples utilized to evaluate retrofit.

RETROFIT TYPE	# of VEH.	GRAMS PER MILE HC	CO	NO_x	ECONOMY MPG
1964-1967 Model-Years					
VSAD/A.BLD.	5	7.7	120	2.6	15.0
VSAD/EGR	8	9.8	155	1.2	13.9
EGR/A.BLD.	7	11.2	157	2.0	12.7
1968-1972 Model-Years					
CATALYTIC	4	5.6	81	2.1	14.3
LPG	3	6.9	95	4.1	11.8
A.BLD.	6	4.2	63	3.1	17.2
EGR	5	5.1	62	2.8	17.2
EGR/A.BLD.	4	4.8	96	2.7	13.3
FBPR	5	5.4	103	2.5	13.0

Table 33. Absolute Baseline Emissions and MPG Data for Sea-Level Retrofit Sample

Table 34 shows the emissions reduction and fuel economy improvements in terms of percent change as a result of retrofit effectiveness.

RETROFIT TYPE	% REDUCTION HC	CO	NO_x	% IMPROVEMENT ECONOMY
1964-1967				
VSAD/A.BLD.	18.6	8.6	46.8	- 8.0
VSAD/EGR	26.1	11.2	27.6	- 0.4
EGR/A.BLD.	22.4	21.2	25.4	2.4
1968-1972				
CATALYTIC	72.3	83.5	- 2.8	1.7
LPG	40.5	53.5	- 3.8	21.7
A.BLD.	17.5	41.8	-23.7	- 0.9
EGR	7.1	2.2	42.8	- 8.8
EGR/A.BLD.	17.0	48.0	28.8	1.7
FBPR	18.0	29.7	-22.6	2.6

Table 34. Percent Emissions Reduction and Fuel Economy Improvement for Sea-Level Retrofits

Based on the data shown in Table 34, the following observations are made:

Catalytic and LPG systems are the most effective for HC and CO reduction.

Systems incorporating Air Bleed and the FBPR system are effective in reducing HC and CO emissions. NO_x emission tends to increase and fuel economy tends to be improved.

Systems incorporating VSAD are effective in reducing HC and NO_x emissions. Fuel economy tends to be decreased.

Systems incorporating EGR are effective in reducing NO_x. EGR in itself causes reduced fuel economy.

Systems incorporating EGR and Air bleed tend to reduce HC, CO and NO_x. Fuel economy tends to be improved.

7.2.2 Cost Effectiveness Data

Cost data including hardware and installation charges were combined with effectiveness data and a CE ratio was developed. Cost effectiveness data for the various sea-level retrofit types are shown in Table 35.

RETROFIT TYPE	MILLIGRAMS/MILE/DOLLAR HC	CO	NO$_x$
1964-1967			
VSAD/A.BLD.	57.4	412.0	47.8
VSAD/EGR	102.7	690.7	13.4
EGR/A.BLD.	67.8	899.6	13.5
1968-1972			
CATALYTIC	25.9	435.8	- 0.4
LPG	4.3	78.5	- 0.2
A.BLD.	29.2	1047.1	-29.0
EGR	11.1	42.4	36.6
EGR/A.BLD.	22.3	1240.1	21.3
FBPR	39.9	1266.6	-23.7

Table 35. Summary of Cost Effectiveness of Sea-Level Retrofit

Summary cost effectiveness and emissions reduction data are combined and are shown in Table 36. This table is also of particular benefit since it is useful in selecting the type of retrofit which would be required to achieve a balance between effectiveness and cost effectiveness.

RETROFIT TYPE	HC (CE)	HC (%)	CO (CE)	CO (%)	NO$_x$ (CE)	NO$_x$ (%)
1964-1967						
VSAD/A.BLD	57.4	18.6	412.0	8.6	47.8	46.8
VSAD/EGR	102.7	26.1	690.7	11.2	13.4	27.6
EGR/A.BLD.	67.8	22.4	899.6	21.2	13.5	25.4
1968-1972						
CATALYTIC	25.9	72.3	435.8	83.5	- 0.4	- 2.8
LPG	4.3	40.5	78.5	53.5	- 0.2	- 3.8
A.BLD.	29.2	17.5	1047.1	41.8	-29.0	-23.7
EGR	11.1	7.1	42.4	2.2	36.6	42.8
EGR/A.BLD.	22.3	17.0	1240.1	48.0	21.3	28.8
FBPR	39.9	18.0	1266.6	29.7	-23.7	-22.6

Table 36. Summary of Combined Cost Effectiveness and Percent Emissions Reduction for Sea-Level Retrofit

7.2.3 Vehicle Driveability and Performance

Driveability and performance affects of the various retrofits are shown in Table 37 where a negative sign (-) indicates a penalty in terms of both driveability demerits and percent change in performance data.

RETROFIT TYPE	DRIVEABILITY (CHG. In DEMERITS)	PERFORMANCE (% CHG.)	
		0-70	70-30
1964-1967			
VSAD/A.BLD.	3	- 6	- 1
VSAD/EGR	- 9	- 3	- 2
EGR/A.BLD.	-30	- 2	-11
1968-1972			
CATALYTIC	30	-13	- 1
LPG	43	-25	12
A.BLD.	- 7	- 3	- 4
EGR	- 1	- 2	4
EGR/A.BLD.	- 7	0	- 2
FBPR	- 1	- 5	2

Table 37. Driveability and Performance Affects of Sea-Level Retrofit

7.3 EXHAUST CONTROL RETROFIT (HIGH ALTITUDE KITS)

The following paragraphs which relate to the evaluation of high altitude kits contain effectiveness and cost effectiveness data. The affects of the high altitude kits are also presented in terms of driveability and performance.

7.3.1 Effectiveness Data

Baseline emissions and fuel economy data is shown in Table 38.

MAKE	# of VEH.	GRAMS PER MILE			ECONOMY
		HC	CO	NO_x	MPG
AMMO	4	5.78	67.3	2.97	13.1
BUIC	6	4.86	100.8	3.01	11.4
CADI	2	3.44	109.5	1.85	9.8
CHEV	26	5.11	72.7	2.63	13.6
CHRY	1	4.29	72.9	2.43	11.5
DODG	6	7.02	101.7	2.37	13.7
FORD	27	5.19	78.3	2.57	14.0
MERC	6	5.13	61.5	3.67	14.0
OLDS	6	4.67	75.0	2.67	12.7
PLYM	8	5.81	102.5	2.14	13.6
PONT	8	4.94	90.3	3.32	12.1
ALL	100	5.23	81.4	2.70	13.3

Table 38. Absolute Baseline Emissions and MPG Data for High Altitude Retrofit Sample

Table 39 shows emission reductions and fuel economy improvement in percent as a result of high altitude kit installations.

As indicated in Table 39, the kits provided by American Motors Corporation caused increases in HC, CO and NO_x emissions and a slight improvement in fuel economy. Kits supplied by General Motors Corporation caused a reduction in CO, except as applied to Oldsmobile, and improvements in fuel economy. GM kits also caused increases in HC and NO_x emissions. Installation of kits furnished by

MAKE	MFGR	% REDUCTION HC	% REDUCTION CO	% REDUCTION NO$_x$	% IMPROVEMENT ECONOMY
AMMO	Ammo	- 9.5	-12.2	- 17.4	1.7
BUIC	GM	- 8.4	8.6	- 19.2	2.3
CADI	GM	-49.3	23.3	-138.9	6.2
CHEV	GM	- 6.5	3.1	- 28.9	4.9
CHRY	Chry	-76.6	6.1	- 40.0	7.7
DODG	Chry	28.2	59.9	- 97.9	8.5
FORD	Ford	0.5	8.0	- 20.2	3.2
MERC	Ford	2.5	13.5	- 3.8	3.1
OLDS	GM	- 8.5	- 6.0	- 23.7	0.5
PLYM	Chry	33.6	54.3	- 79.3	9.6
PONT	GM	2.3	18.3	- 23.7	2.8
ALL		1.4	15.6	- 31.1	4.3

Table 39. Percent Emissions Reduction and Fuel Economy Improvement for High Altitude Kits

Chrysler Corporation resulted in CO reductions and a HC reduction except as applied to a Chrysler make (1 car in sample). Chrysler supplied kits generally caused NO$_x$ emission to increase and fuel economy to improve. Kits provided by Ford Motor Company caused CO reductions and slight reductions in HC. Fuel economy improved and NO$_x$ emissions increased. With respect to the overall sample the kits caused a 1.4 percent decrease in HC, a 15.6 decrease in CO, a 31.1 percent increase in NO$_x$ and a 4.3 percent improvement in fuel economy.

7.3.2 Cost Effectiveness

Cost data, including both installation and parts costs, were combined with emissions data and a cost effectiveness ratio was developed. The CE ratio as determined by vehicle make is shown in Table 40.

MAKE	MILLIGRAMS/MILE/DOLLAR HC	MILLIGRAMS/MILE/DOLLAR CO	MILLIGRAMS/MILE/DOLLAR NO$_x$
AMMO	- 71.6	-1073.8	- 67.5
BUIC	- 32.3	689.2	- 45.8
CADI	-138.9	2090.2	-210.1
CHEV	- 27.6	188.0	- 63.4
CHRY	-366.9	493.9	-108.7
DODG	201.1	6175.9	-235.0
FORD	2.6	653.7	- 54.3
MERC	12.3	810.0	- 13.5
OLDS	- 30.2	- 343.6	- 48.2
PLYM	229.7	6541.9	-199.2
PONT	7.8	1148.2	- 54.6
ALL	6.9	1161.1	- 76.7

Table 40. Summary of Cost Effectiveness of High Altitude Kits

As indicated in Table 40, the cost effectiveness range is wide. CE ratios for HC vary from -366.9 to 229.7. For CO the CE ratio ranges from a low of -1073.8 to a high of 6541.9 and for NO the range is from -235.0 to -13.5.

Table 41 is comprised of summary data showing emissions reduction in percent and corresponding cost effectiveness ratios.

MAKE	HC		CO		NO_x	
	(CE)	(%)	(CE)	(%)	(CE)	(%)
AMMO	- 71.6	- 9.5	-1073.8	-12.2	- 67.5	- 17.4
BUIC	- 32.3	- 8.4	689.2	8.6	- 45.8	- 19.2
CADI	-138.9	-49.3	2090.2	23.3	-210.1	-138.8
CHEV	- 27.6	- 6.5	188.0	3.1	- 63.4	- 28.9
CHRY	-366.9	-76.6	493.9	6.1	-108.7	- 40.0
DODG	201.1	28.2	6175.9	59.9	-235.0	- 97.9
FORD	2.6	0.5	653.7	8.0	- 54.3	- 20.2
MERC	12.3	2.5	810.0	13.5	- 13.5	- 3.8
OLDS	- 30.2	- 8.5	- 343.6	- 6.0	- 48.2	- 23.7
PLYM	229.7	33.6	6541.9	54.3	-199.2	- 79.3
PONT	7.8	2.3	1148.2	18.3	- 54.6	- 23.7
ALL	6.9	1.4	1161.1	15.6	- 76.7	- 31.1

Table 41. Summary of Combined Cost Effectiveness and Percent Emissions Reduction for High Altitude Kits

7.3.3 Driveability and Performance Affects

Changes in driveability and performance are shown in Table 42.

MAKE	DRIVEABILITY	PERFORMANCE (% CHG)	
	(CHG. in DEMERITS)	0-70	70-30
AMMO	-11	-2	4
BUIC	- 3	-3	- 4
CADI	11	-5	20
CHEV	2	-5	1
CHRY	-28	-8	12
DODG	- 8	0	2
FORD	0	2	- 6
MERC	- 2	-2	- 7
OLDS	-24	-1	-10
PLYM	- 9	-5	- 4
PONT	2	-3	- 4
ALL	- 3		

Table 42. Driveability and Performance Affects of High Altitude Kits

7.4 MODIFIED TUNING SPECIFICATIONS

The following paragraphs relate to the results that were obtained in the evaluation of modified tuning specifications. Cost data is not applicable.

7.4.1 Effectiveness

In Table 43 is shown the emission reductions and fuel economy improvements which were obtained as a result of modified tuning specifications. The experiment was designed primarily to reduce CO emissions. Substantial CO reductions were achieved as a result of the strategy. In addition, several combinations of modified adjustments resulted in slight HC reductions and improvements in fuel economy. All combinations resulted in slight increases in NO_x. The following is offered to explain the method by which summary data were obtained.

PARAMETERS AT EXPERIMENTAL SETTINGS	# of TESTS	% REDUCTION			% IMPROVEMENT
		HC	CO	NOx	ECONOMY
SINGLE ITEMS					
A/F RATIO	99	9.5	25.0	-29.2	0.2
BASIC TIMING	100	-4.4	16.8	-34.5	0.9
IDLE RPM	100	2.5	14.0	-26.7	-1.8
CHOKE	100	-0.6	16.6	-28.7	-0.3
COMBINATIONS OF 2					
A/F-TIMING	50	3.7	27.7	-38.4	1.8
A/F-RPM	50	8.6	24.9	-31.1	-0.9
A/F-CHOKE	51	9.0	28.6	-32.6	0.3
TIMING-RPM	50	-2.9	17.3	-35.9	-0.6
TIMING-CHOKE	51	-8.5	20.9	-37.8	1.3
RPM-CHOKE	50	-0.5	16.2	-31.4	-1.4
A/F-TIMING ONLY	23	4.9	22.2	-33.4	2.7
A/F-RPM ONLY	25	15.3	20.4	-16.0	-2.4
A/F-CHOKE ONLY	24	16.9	24.3	-16.8	-0.6
TIMING-RPM ONLY	24	-2.7	4.4	-27.0	-2.3
TIMING-CHOKE ONLY	23	-14.4	7.0	-30.3	1.0
RPM-CHOKE ONLY	24	2.4	2.5	-13.4	-4.0
COMBINATIONS OF 4					
ALL PARAMETERS	25	2.7	29.8	-41.6	0.5
MRGRS. SPECS.	25	0.0	0.0	0.0	0.0

Table 43. Percent Emissions Reduction and Fuel Economy Improvement for Modified Tuning Specifications

It should be remembered that 8 tests were conducted on each of 25 cars for a total of 200 tests. Generally, each parameter was adjusted to the experimental value in combination with one other parameter except that in one case all parameters were adjusted to experimental values (ALL PARAMETERS) and in one other case none of the parameters were adjusted to experimental values (MFGRS. SPECS.). In viewing each parameter individually then, each parameter set to the experimental value appears in 100 tests. In viewing a combination of two parameters without regard for other parameters, a combination of two appears in 50 tests. The combination of two parameters set to experimental values by itself appears in 25 tests*.

---

*Because of an error in the adjustment sequence which was not noticed until testing was completed, the absolute number of tests prescribed at each experimental setting was not performed. Data shown in Table 43 is based on the actual number of tests performed at prescribed settings.

7.4.2 Driveability and Performance Affects

The results of driveability and performance tests are shown in Table 44 where data is averaged at each of the test conditions shown.

PARAMETERS AT EXPERIMENTAL SETTINGS	# of TESTS	DRIVEABILITY (CHG. in DEMERITS)	PERFORMANCE (% CHG) 0-70	PERFORMANCE (% CHG) 70-30
SINGLE ITEMS				
A/F RATIO	99	- 9	- 4	-10
BASIC TIMING	100	-10	- 4	- 9
IDLE RPM	100	- 9	- 5	-12
CHOKE	100	-11	- 6	- 9
COMBINATIONS OF 2				
A/F-TIMING	50	-11	- 5	- 9
A/F-RPM	50	-10	- 5	-13
A/F-CHOKE	51	-12	- 5	-10
TIMING-RPM	50	-12	- 4	-12
TIMING-CHOKE	51	-13	- 5	- 9
RPM-CHOKE	50	-12	- 8	-12
A/F-TIMING ONLY	23	- 6	- 4	- 4
A/F-RPM ONLY	25	- 4	- 4	-14
A/F-CHOKE ONLY	24	- 9	- 3	- 6
TIMING-RPM ONLY	24	- 8	- 2	-10
TIMING-CHOKE ONLY	23	-11	- 5	- 4
RPM-CHOKE ONLY	24	- 8	-10	-11
COMBINATIONS OF 4				
ALL PARAMETERS	25	-16	- 6	-13
MFGRS. SPECS.	25	0		

Table 44. Driveability and Performance Affects of Modified Tuning Specifications

It should be noted that for the most part, each of the strategies applied which involve modification to engine parameters normally resulted in some deterioration in driveability and performance. It has been mentioned earlier that standards in performance are non-existent aside from a simple comparison of one condition to another. With respect to the data shown above, a demerit change of about -10, a 0-70 mph change of -5% and a 70-30 mph change of -5 to -10% would probably be acceptable.

7.5 MANDATORY ENGINE MAINTENANCE

The paragraphs which follow relate to effectiveness and cost effectiveness for mandatory engine maintenance. Driveability and performance data were not developed.

7.5.1 Effectiveness

baseline data for mandatory engine maintenance are shown in Table 45. Percent emissions reduction and fuel economy improvement are shown in Table 46.

MAKE	# of VEH	GRAMS PER MILE HC	GRAMS PER MILE CO	GRAMS PER MILE NO	ECONOMY MPG
AMMO	4	6.60	99.2	2.41	12.7
BUIC	6	5.92	127.4	2.45	11.3
CADI	2	3.80	111.3	1.84	9.9
CHEV	41	8.85	110.3	2.57	13.1
CHRY	1	4.63	73.8	2.43	11.9
DODG	9	7.68	106.4	2.79	14.3
FORD	45	7.19	88.3	3.02	14.4
MERC	6	5.31	62.3	3.24	14.7
OLDS	8	6.70	117.8	2.33	11.9
PLYM	15	8.57	129.6	2.27	13.4
PONT	13	7.40	113.7	2.84	12.3
VOLK	5	5.41	80.3	1.89	21.2
ALL	155	7.53	103.6	2.68	13.6

Table 45. Absolute Baseline Emissions and MPG Data for Mandatory Engine Maintenance Sample

MAKE	# of VEH	% REDUCTION HC	% REDUCTION CO	% REDUCTION NO	% IMPROVEMENT ECONOMY
AMMO	4	12.4	32.1	-23.3	3.0
BUIC	6	17.8	20.1	-22.8	1.4
CADI	2	9.4	1.6	- 0.6	-1.1
CHEV	41	30.4	12.5	12.0	2.6
CHRY	1	7.4	1.2	0.1	-3.7
DODG	9	- 1.2	- 9.1	19.4	-1.4
FORD	45	12.9	3.4	15.5	-0.1
MERC	6	3.5	1.3	-13.5	-4.6
OLDS	8	16.2	16.0	- 1.7	5.1
PLYM	15	26.9	13.1	6.7	2.1
PONT	13	16.2	7.9	1.3	1.1
VOLK	5	8.4	6.5	14.3	4.7
ALL	155	19.2	9.1	8.2	1.2

Table 46. Percent Emissions Reduction and Fuel Economy Improvement for Mandatory Engine Maintenance

7.5.2 Cost Effectiveness

Costs, including both parts and flat rate manual labor rates and associated costs, were combined with emissions data and cost effectiveness data for mandatory engine maintenance were developed as shown in Table 47. Mandatory maintenance appears to be cost effective with respect to several of the various makes and less so for several of the others. On the average it appears that mandatory engine maintenance is less cost effective than certain of the other strategies investigated particularly as related to CO emissions. In Table 48 is shown percent emissions reduction and cost effectiveness data.

MAKE	MILLIGRAMS/MILE/DOLLAR		
	HC	CO	NO_x
AMMO	24.6	955.9	-16.9
BUIC	17.9	453.2	- 9.5
CADI	6.1	29.9	- 0.2
CHEV	48.4	248.1	5.5
CHRY	7.7	20.5	0.0
DODG	- 2.1	-222.6	12.5
FORD	21.4	69.4	10.9
MERC	4.1	18.4	- 9.7
OLDS	18.8	327.1	- 0.7
PLYM	52.9	387.3	3.5
PONT	20.8	156.2	0.7
VOLK	13.1	151.8	7.8
ALL	29.6	192.7	4.5

Table 47. Summary of Cost Effectiveness for Mandatory Engine Maintenance

MAKE	HC		CO		NO_x	
	(CE)	(%)	(CE)	(%)	(CE)	(%)
AMMO	24.6	12.4	955.9	32.1	-16.9	-23.3
BUIC	17.9	17.8	453.2	20.9	- 9.5	-22.8
CADI	6.1	9.4	29.9	1.6	- 0.2	- 0.6
CHEV	48.4	30.4	248.1	12.5	5.5	12.0
CHRY	7.7	7.4	20.5	1.2	0.0	0.1
DODG	- 2.1	- 1.2	-222.6	- 9.1	12.5	19.4
FORD	21.4	12.9	69.4	3.4	10.9	15.5
MERC	4.1	3.5	18.4	1.3	- 9.7	-13.5
OLDS	18.8	16.2	327.1	16.0	- 0.7	- 1.7
PLYM	52.9	26.9	387.3	13.1	3.5	6.7
PONT	20.8	16.2	156.2	7.9	0.7	1.3
VOLK	13.1	8.4	151.8	6.5	7.8	14.3
ALL	29.6	19.2	192.7	9.1	4.5	8.2

Table 48. Summary of Combined Cost Effectiveness and Emissions Reduction for Mandatory Engine Maintenance

7.6 OBSERVATIONS

Table 49 has been prepared from data presented and discussed in previous sections. The Table has been prepared to show on a relative basis the effectiveness and cost effectiveness of each of the strategies investigated. The basis for costs and effectiveness are derived from data presented in previous sections except as applied to modified tuning specifications where cost data were not developed. To develop the CE data for modified tuning specifications it was first assumed that two of the adjustments in combination would produce reductions of 10% HC, 20% CO and -20% NO_x. Examination of percent reductions for modified tuning specifications as shown in Table 43 will verify this assumption to be correct (adjustments involving A/F ratio alone, A/F and choke, A/F and rpm only and A/F and choke only). It was then assumed that costs to adjust

STRATEGY	HC		CO		NO_x		ECON.BENE.
IDLE INSP.	(CE)	(%)	(CE)	(%)	(CE)	(%)	(%)
20%	80	8	500	3	3	1	1
30%	100	10	750	5	3	1	1
40%	100	11	850	7	4	1	1
50%	100	12	950	8	4	1	1
60%	100	13	1000	9	5	2	2
RETROFIT							
CATALYTIC	25	75	450	85	0	0	0
LPG	5	40	75	55	0	- 5	21
EGR/A.BLD	50	20	1000	30	15	25	2
A.BLD-FBPR	25	20	1150	35	-25	-25	2
VSAD/A.BLD	60	20	400	10	50	45	- 8
HIGH ALT.KIT	5	1	1150	15	-75	-30	4
MOD.TUN.SPEC.	100	10	4000	20	-20	-20	0
MAND.MAINT.	30	20	200	10	5	10	1

Table 49. Summarized Cost Effectiveness and Emissions Reduction Data for Strategies Investigated

any two of the parameters would be $5.00. Effectiveness data (as assumed) and cost data (5.00/two adjustments) were combined and a cost effectiveness ratio was established for modified tuning specifications.

With respect to emissions and cost data as represented and without regard for other factors, the following observations are developed.

1. Each of the strategies investigated is effective in reducing HC and CO emissions.

   The range of reduction for HC is from about 1% for the high altitude kits to about 75% for catalytic retrofit.

   CO reduction ranges from a low of about 3% for an idle emissions rejection rate of 20% to about 85% for catalytic retrofit.

   The range of reduction for NO_x emissions is from about -30% for the high altitude kits to about 45% for the VSAD/Air Bleed retrofit system.

2. Each of the strategies generally produced slight increases in fuel economy. An 8% decrease in fuel economy was measured for application of VSAD/Air Bleed, however.

3. The range of cost effectiveness is wide:

   CE for HC ranges from low of about 5 milligrams/mile/dollar (mmd) for the high altitude kits to a high of about 100 mmd for idle emission rejection rates at 30% and above and 100 mmd for the more effective modified tuning specifications.

   CE for CO ranges from a low of about 75 mmd for LPG conversion to a high of about 4000 mmd for the more effective modified tuning specifications.

   CE for NO_x ranges from a low of -75 mmd for the high altitude kits to a high of about 50 mmd for VSAD/Air Bleed retrofit.

4. Of the various idle emission rejection rates, rejection of failed vehicles at about the 40% rejection level appears to be about optimum for CO and HC reduction. At 40% rejection:

CE for HC is optimum and HC reduction is relatively high.

CE for CO is well up toward the optimum level and CO reduction is relatively high. (A 50% rejection level gains 1% additional CO reduction but a 30% rejection level loses 2% CO reduction).

Both CE and % reduction for NO_x emission are near optimum.

5. Of the sea-level retrofits investigated:

   Catalytic and LPG systems represent the highest level of CO and HC reduction.

   For reasons relating to initial costs, fuel availability, etc., the VSAD/EGR, EGR/Air Bleed, Air Bleed and Float Bowl Pressure Regulation (FBPR) systems are probably more suitable for broad application to passenger cars in Colorado. It may be desirable to limit the application to VSAD/EGR and EGR/Air Bleed systems in view of the relatively large increases in NO_x emission attributed to Air Bleed and FBPR systems.

   Catalytic and LPG systems could be applied in fleet operations where costs and special fuel requirements for LPG would be borne by business as opposed to individuals.

6. Of the high altitude kits investigated:

   All kits generally caused an increase in NO_x emissions and an improvement in fuel economy.

   The GM supplied kits generally increased HC emissions and reduced CO emissions.

   The Ford supplied kits generally lowered HC emissions (slightly) and reduced CO emissions.

   The Chrysler supplied kits generally lowered HC and CO emissions (except on the one Chrysler make in the sample).

   The American Motors supplied kits generally caused increases in HC and CO.

7. Modification of tuning specifications proved to be an effective and cost effective HC and CO reduction strategy although NO_x emissions were generally increased. Of the parameters investigated:

   The experimental A/F ratio setting appears to be the most effective in reducing HC and CO. In combination A/F ratio and choke experimental settings appear to be the most effective in reducing HC and CO. A/F ratio and rpm experimental adjustments are also very effective in reducing HC and CO.

   Certain of the more effective HC and CO reducing combinations of adjustment are the most cost effective of all strategies investigated.

8. Mandatory engine maintenance was effective in reducing HC, CO and NO_x emissions. However, mandatory engine maintenance is one of the least cost effective of all strategies investigated.

As a final note it should be observed that emissions reductions and cost effectiveness are additive with respect to certain combinations of strategies. For example: all retrofit effectiveness and cost effectiveness data are additive with respect to the effectiveness and cost data developed for mandatory engine maintenance since all vehicles utilized in retrofit samples were tuned-up prior to retrofit installation. In this respect the following applies:

> Sea-level retrofit reductions can be added to mandatory engine maintenance with the possible exception of catalytic and LPG systems.
>
> High altitude kit reductions can be added to mandatory engine maintenance.
>
> Modified tuning specification reductions can be added to mandatory engine maintenance.

Beyond the three combinations mentioned a simple relationship does not exist. To combine these affects, it should be realized that absolute emissions reductions and costs must be taken into account as opposed to a direct combination of reduction data by percent.

LIST OF REFERENCES

1. State of Colorado, Department of Health; the State of Colorado Air Pollution Control Transportation and Land Use Plan; May 14, 1973.

2. A Study of Emissions from Light-Duty Vehicles in Denver, Houston and Chicago, Fiscal Year 1972. Environmental Protection Agency, Office of Air and Water Programs, Certification and Surveillance Division, Ann Arbor, Michigan, Contract No. 68-01-0455 to Automotive Testing Laboratories, Inc. Publication No. APDT-1504. July, 1973. 14 p.

3. Wiers, Ward W., and Scheffler, Charles E., "Carbon Dioxide (CO_2) Tracer Technique for Modal Mass Exhaust Emission Measurement", SAE Paper 720126 (January 10-14, 1972).

APPENDICES

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APPENDIX 1

TEST VEHICLE FLOW CHARTS

Before testing commenced, flow charts for the possible test sequences were constructed as are shown on the following pages (Figures 1 through 5). These were constructed to assure that all required data were collected while performing no unnecessary testing. A further benefit was the insurance that vehicles would leave the testing program in a known condition* and, therefore, be available for a subsequent deterioration test program.

---

*Vehicles undergoing a Combination Retrofit Test sequence (Figure 4) would not be available for deterioration studies. However, investigation revealed only a maximum of 19 vehicles would go through this sequence. It was not felt that this number would detract from the deterioration program.

INSPECTION AND MAINTENANCE TESTS

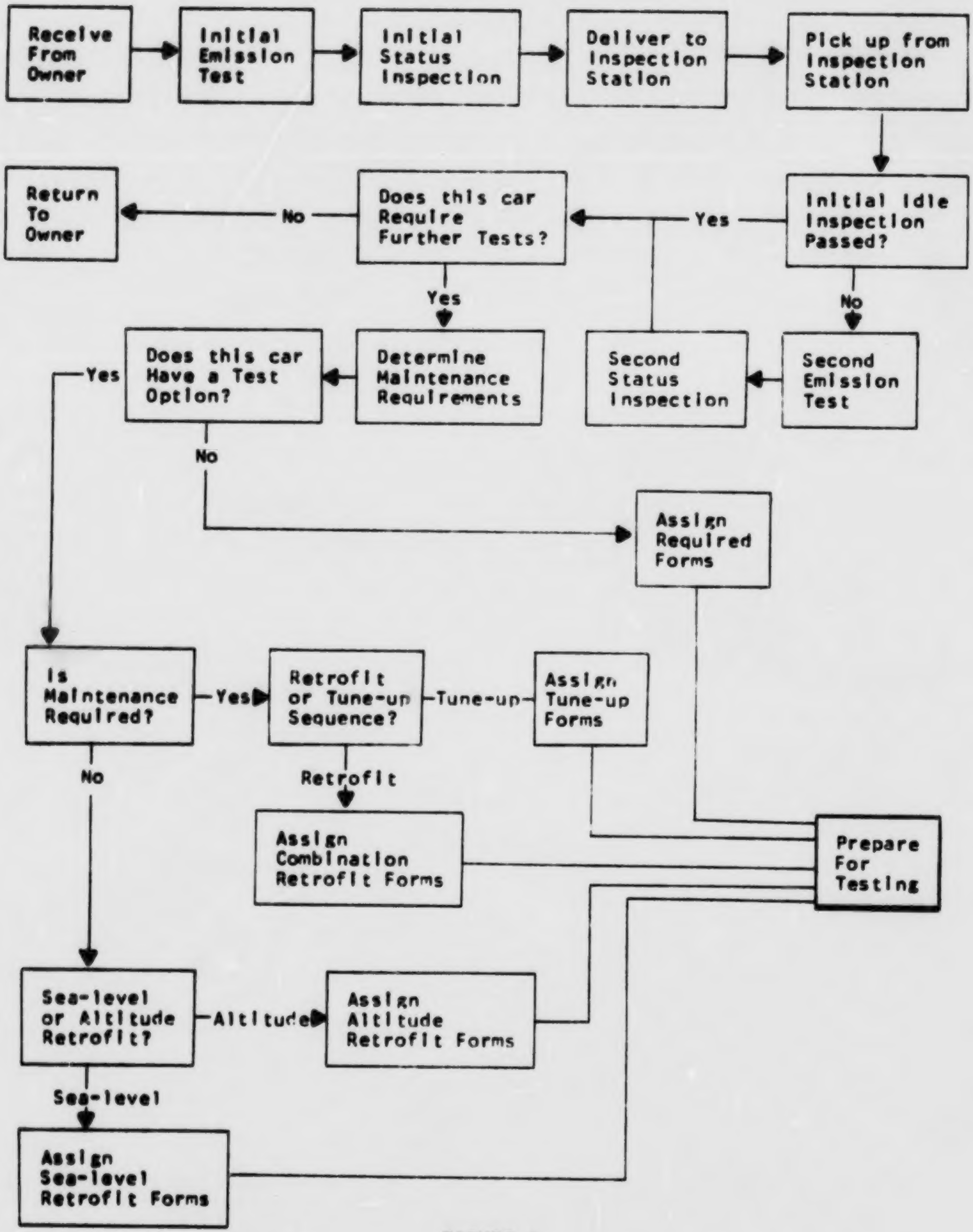

Receive From Owner
Initial Emission Test
Initial Status Inspection
Deliver to Inspection Station
Pick up from Inspection Station
Initial Idle Inspection Passed?
Yes
No
Does this car Require Further Tests?
No
Return To Owner
Yes
Second Emission Test
Second Status Inspection
Determine Maintenance Requirements
Does this car Have a Test Option?
Yes
No
Assign Required Forms
Is Maintenance Required?
Yes
Retrofit or Tune-up Sequence?
Tune-up
Assign Tune-up Forms
Retrofit
Assign Combination Retrofit Forms
Prepare For Testing
No
Sea-level or Altitude Retrofit?
Altitude
Assign Altitude Retrofit Forms
Sea-level
Assign Sea-level Retrofit Forms

FIGURE 1

SEA-LEVEL RETROFIT TESTS

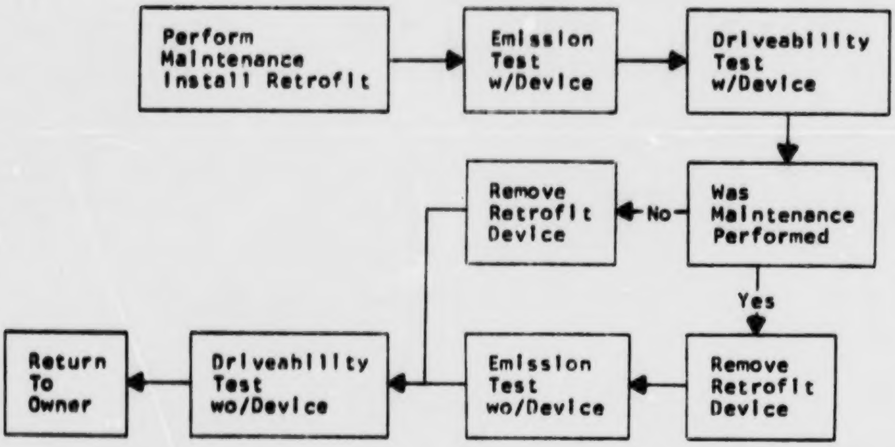

Perform Maintenance Install Retrofit
Emission Test w/Device
Driveability Test w/Device
Was Maintenance Performed
No
Remove Retrofit Device
Yes
Remove Retrofit Device
Emission Test wo/Device
Driveability Test wo/Device
Return To Owner

FIGURE 2

ALTITUDE RETROFIT TESTS

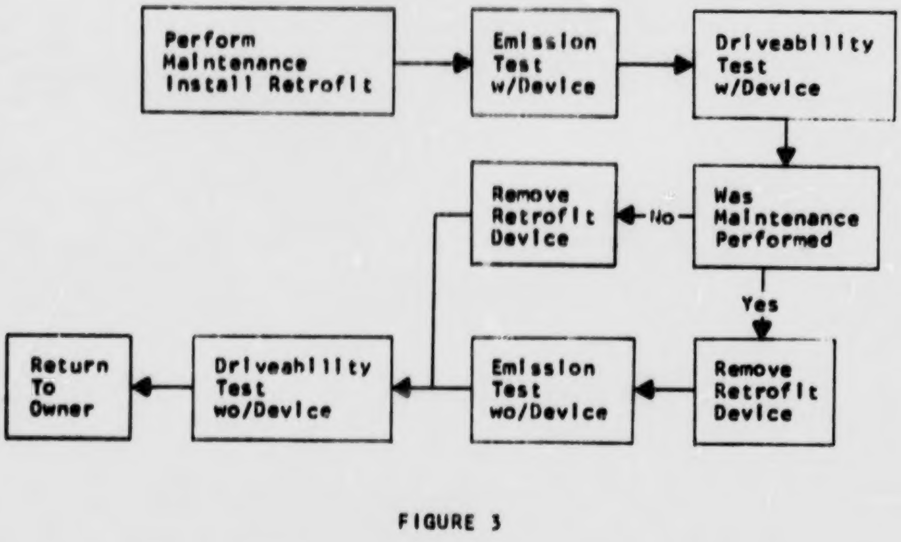

Perform Maintenance Install Retrofit
Emission Test w/Device
Driveability Test w/Device
Was Maintenance Performed
No
Remove Retrofit Device
Yes
Remove Retrofit Device
Emission Test wo/Device
Driveability Test wo/Device
Return To Owner

FIGURE 3

COMBINATION RETROFIT TESTS

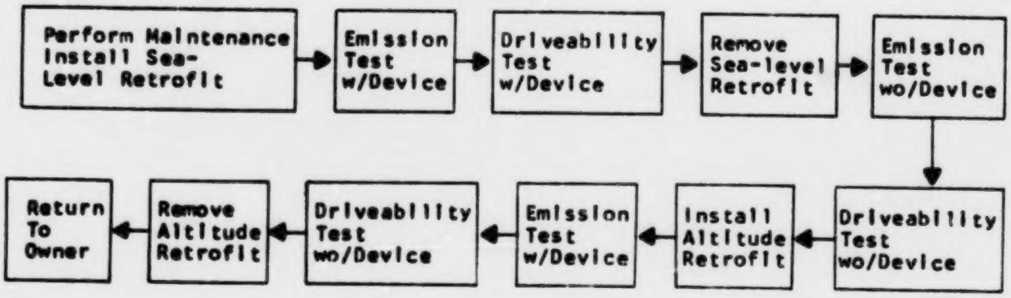

Perform Maintenance Install Sea-Level Retrofit
Emission Test w/Device
Driveability Test w/Device
Remove Sea-level Retrofit
Emission Test wo/Device
Driveability Test wo/Device
Install Altitude Retrofit
Emission Test w/Device
Driveability Test wo/Device
Remove Altitude Retrofit
Return To Owner

FIGURE 4

MODIFIED TUNING SPECIFICATION TESTS

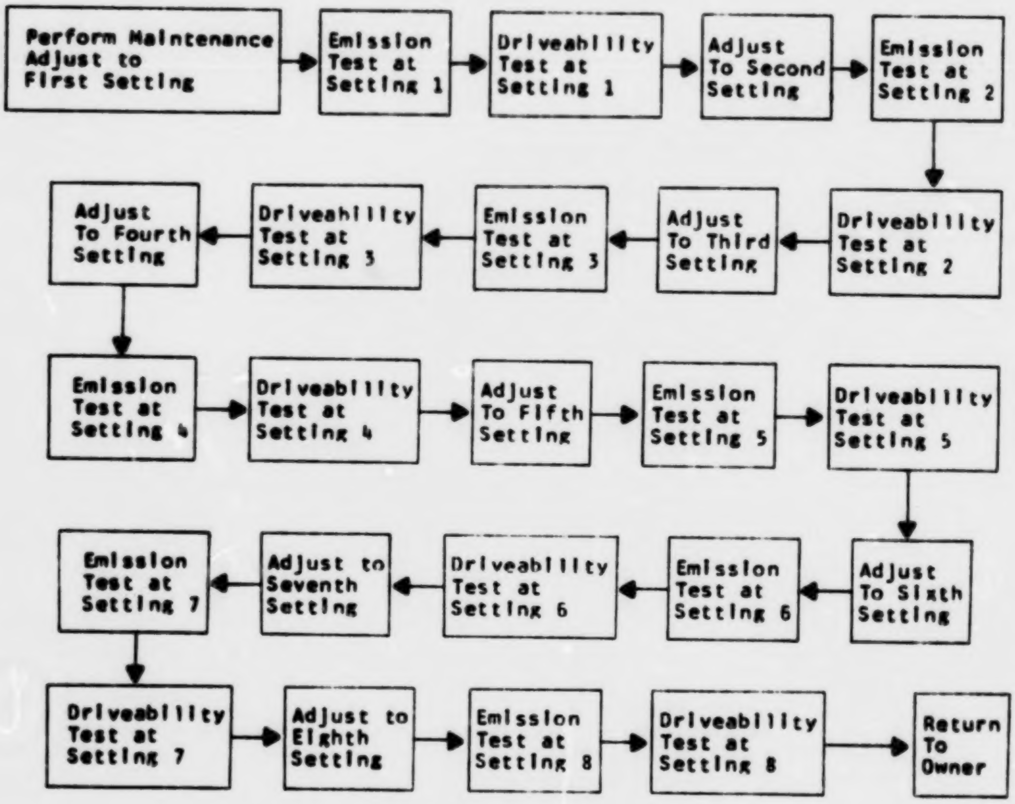

Perform Maintenance Adjust to First Setting
Emission Test at Setting 1
Driveability Test at Setting 1
Adjust To Second Setting
Emission Test at Setting 2
Driveability Test at Setting 2
Adjust To Third Setting
Emission Test at Setting 3
Driveability Test at Setting 3
Adjust To Fourth Setting
Emission Test at Setting 4
Driveability Test at Setting 4
Adjust To Fifth Setting
Emission Test at Setting 5
Driveability Test at Setting 5
Adjust To Sixth Setting
Emission Test at Setting 6
Driveability Test at Setting 6
Adjust to Seventh Setting
Emission Test at Setting 7
Driveability Test at Setting 7
Adjust to Eighth Setting
Emission Test at Setting 8
Driveability Test at Setting 8
Return To Owner

FIGURE 5

APPENDIX 2

DATA ACCUMULATION FORMS

The various data forms were designed following the construction of vehicle flow charts. Each is designed to collect the data generated at a major test point indicated on the flow charts of Appendix 1.

The forms were utilized as follows:

1. Vehicle Information (Figure 1)

   The vehicle number was assigned and critical information obtained from the owner was recorded at the time the vehicle was scheduled by the procurement specialist. This information was confirmed at the time the vehicle was accepted for testing to insure compliance to sample specifications. The other data blanks were also filled in at the time of vehicle acceptance.
2. Emission Test (Figure 2)

   This information was collected during the Federal Mass Emission Test, the Keymode Test, and the Idle Emission Test.
3. Maintenance Status Information (Figure 3)

   This inspection was performed following each emission test of the Idle Emission Inspection Evaluation.
4. Inspection Station Results (Figure 4)

   The information recorded on this form was collected by the Inspector and mechanic at the inspection station.
5. Warm Vehicle Driveability Test Form (Figure 5)

   The driveability information was taken during the driveability test following each emission test of the Retrofit Evaluation and the Modified Tuning Evaluation.

VEHICLE INFORMATION

TEST SEQUENCE ____________ VEHICLE NO. ____________

YEAR	MAKE	MODEL	ODOMETER

CYL	CID	BBL	TRN	IN.WT.	HP	EMC	EVC	PCV

(E | | | F)

VEHICLE INSPECTION

LICENSE NO.	STATE	FEDERAL I.D. NO.

Antenna ____________
Left rear fender ____________
Left door(s) ____________
Left front fender ____________
Hood ____________
Grille ____________
Front bumper ____________
Right front fender ____________
Right door(s) ____________
Right rear fender ____________
Miscellaneous ____________

Trunk lid ____________
Rear end ____________
Rear bumper ____________
Top ____________
Window glass ____________
Tires ____________
Hub caps ____________
Mirrors ____________
Interior ____________
Tape Deck? Yes____ No____

Agreed to ____________ (Date), by ____________ (Initial)

NAME ____________ PHONE:HOME ____________ WORK ____________

INCOMING DATE AND TIME ____________

INSPECTION STATION ____________

CONDITION WHEN RETURNED

Odometer ____________ Date ____________

Condition ____________

Check # ____________ Initial ____________

Punched ______
Input Proofed ______
Input Corrected ______
veh. Info. Proofed ______

SEALED ________ by ______

Automotive Testing Laboratories, Inc.

FIGURE 1

EMISSION TEST

LINE NO. ______ INSTRUMENT SET ______

TEST NO. ______ DATE ______ VEH.NO. ______

BAROMETER ______ DRY BULB ______ WET BULB ______

50 MPH LOAD ______ INERTIA WT. ______ TIME ______

OPERATOR ______ DRIVER ______

EPA TEST

	HC	CO	CO_2	NO_x	LHC
COLD TRANS. BKGND					
COLD TRANS. SAMPLE					
COLD STAB. BKGND					
COLD STAB. SAMPLE					
HOT TRANS. BKGND					
HOT TRANS. SAMPLE					

	BLOWER REV.	PRESSURE
COLD TRANSIENT		
COLD STABILIZED		
HOT TRANSIENT		

KEYMODE

	HC	CO	CO_2	NO_x	LHC
IDLE					
LOW CRUISE					
HIGH CRUISE					

			MISFIRE	NO_xCONTROL OK?
SUN IDLE				
SUN LOW CRUISE			YES NO	NA YES NO
SUN HIGH CRUISE			YES NO	NA YES NO
SUN 2500 RPM				

Emission Test Proofed ______
chart Proofed ______
input Punched ______
input Proofed ______
input Corrected ______
Output ______

Automotive Testing Laboratories, Inc.

FIGURE 2

MAINTENANCE STATUS INFORMATION

TEST NO.__________ VEH.NO.__________ DATE__________

As Received From Owner

1. Points/Condenser ok? YES NO
2. Distributer cap ok? YES NO
3. Ignition wires ok? YES NO

4. Air Pump ok? NA YES NO

5. Idle RPM ______ - (MS) ______ = ______

6. Timing Degrees ______ - (MS) ______ = ______

7. Dwell ______ - (MS) ______ = ______

8. PCV ok? NA YES NO

9. Air Cleaner ok? YES NO

10. Choke ok? (Vacuum kick & heat riser) NA YES NO

11. Idle CO MS ______ ______

12. Misfire? YES NO

13. NO_x Control ok? NA YES NO

- -

As Returned From Inspection Station

1. Points/Condenser ok? YES NO
2. Distributer cap ok? YES NO
3. Ignition wires ok? YES NO

4. Air Pump ok? NA YES NO

5. Idle RPM ______ - (MS) ______ = ______

6. Timing Degrees ______ - (MS) ______ = ______

7. Dwell ______ - (MS) ______ = ______

8. PCV ok? NA YES NO

9. Air Cleaner ok? YES NO

10. Choke ok? (Vacuum kick & heat riser) NA YES NO

11. Idle CO MS ______ ______

12. Misfire? YES NO

13. NO_x Control ok? NA YES NO

Info. Proofed ______
Input Punched ______
Input Proofed ______

Automotive Testing Laboratories, Inc.

Input Corrected______
output______

FIGURE 3

INSPECTION STATION RESULTS

INSPECTION STATION ________________________________

VEHICLE NO. ____________________ DATE ____________________

Circle High(H) or Low(L) Scale, PASS or FAIL

INITIAL INSPECTION

IDLE HC H L ________________ 2500 RPM HC H L ________________ PASS FAIL

IDLE CO H L ________________ 2500 RPM CO H L ________________ PASS FAIL

COST ________________

ADJUST IDLE RPM? YES NO

IDLE HC H L ________________ 2500 RPM HC H L ________________ PASS FAIL

IDLE CO H L ________________ 2500 RPM CO H L ________________ PASS FAIL

COST ________________

ADJUST IDLE MIXTURE? YES NO ADJUST TIMING? YES NO

IDLE HC H L ________________ 2500 RPM HC H L ________________ PASS FAIL

IDLE CO H L ________________ 2500 RPM CO H L ________________ PASS FAIL

COST ________________

ADJUST IDLE MIXTURE? YES NO ADJUST TIMING? YES NO

IDLE HC H L ________________ 2500 RPM HC H L ________________ PASS FAIL

IDLE CO H L ________________ 2500 RPM HC H L ________________ PASS FAIL

COST ________________

REPAIRS ____

____

____

COST OF ABOVE REPAIRS ____________________

FINAL INSPECTION

IDLE HC H L ________________ 2500 RPM HC H L ________________ PASS FAIL

IDLE CO H L ________________ 2500 RPM CO H L ________________ PASS FAIL

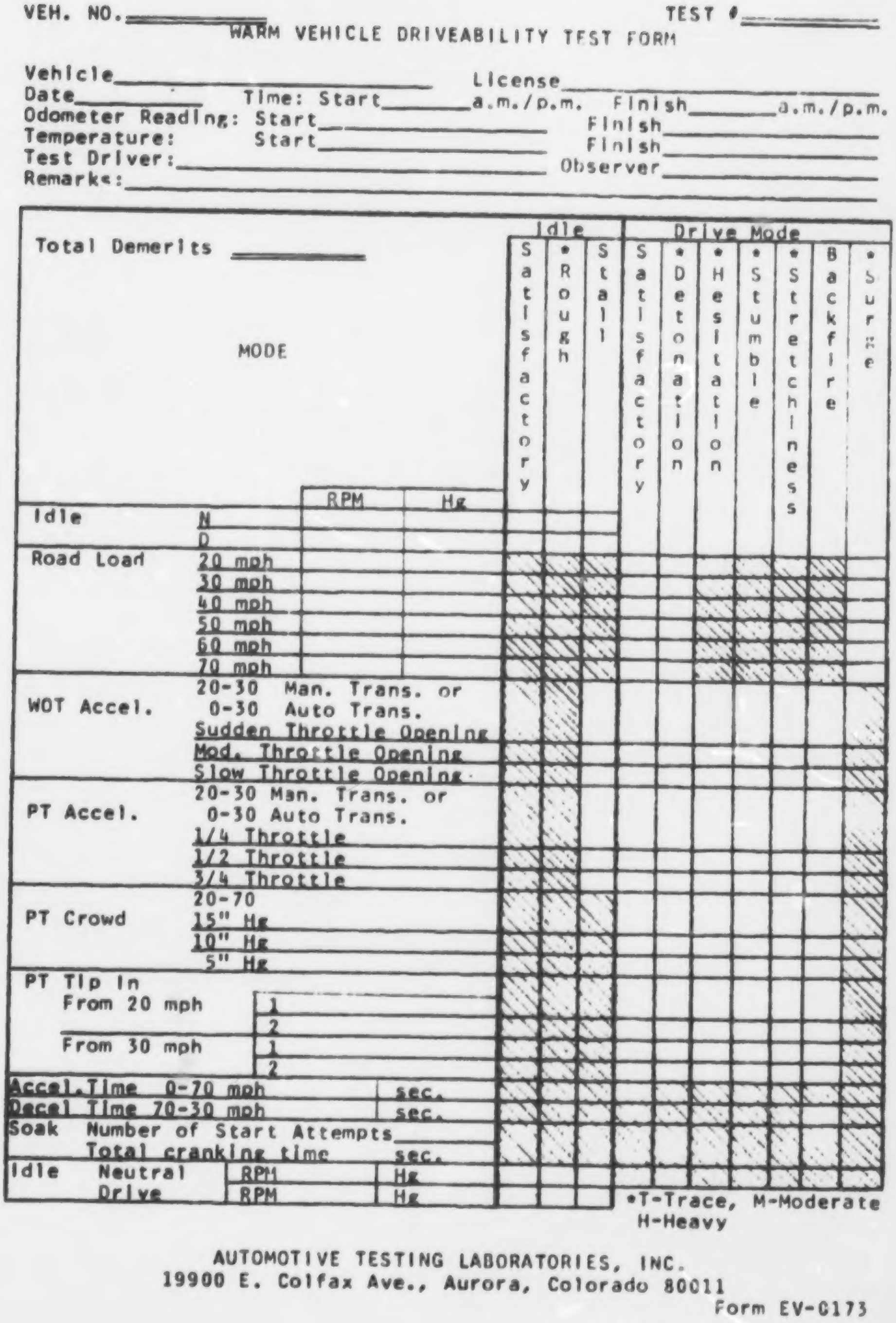
IF THE CAR STILL FAILS, WHAT IS THE
ESTIMATED COST TO BRING INTO COMPLIANCE? ____________________

Results Proofed ______
Input Punched ______
Input Proofed ______

Automotive Testing Laboratories, Inc.

Input Corrected______
Output______

FIGURE 4



VEH. NO.__________ TEST #__________

WARM VEHICLE DRIVEABILITY TEST FORM

Vehicle______________________ License______________________
Date__________ Time: Start______a.m./p.m. Finish______a.m./p.m.
Odometer Reading: Start______________ Finish______________
Temperature: Start______________ Finish______________
Test Driver:______________________ Observer______________
Remarks:____

Total Demerits __________

				Idle			Drive Mode						
MODE		RPM	Hg	Satisfactory	*Rough	Stall	Satisfactory	*Detonation	*Hesitation	*Stumble	*Stretchiness	Backfire	*Surge
Idle	N												
	D												
Road Load	20 mph			▨	▨	▨				▨	▨	▨	
	30 mph			▨	▨	▨			▨	▨	▨	▨	
	40 mph			▨	▨	▨			▨	▨	▨	▨	
	50 mph			▨	▨	▨			▨	▨	▨	▨	
	60 mph			▨	▨	▨			▨	▨	▨	▨	
	70 mph			▨	▨	▨			▨	▨	▨	▨	
WOT Accel.	20-30 Man. Trans. or 0-30 Auto Trans. Sudden Throttle Opening			▨	▨								▨
	Mod. Throttle Opening			▨	▨								▨
	Slow Throttle Opening			▨	▨								▨
PT Accel.	20-30 Man. Trans. or 0-30 Auto Trans. 1/4 Throttle			▨	▨								▨
	1/2 Throttle			▨	▨								▨
	3/4 Throttle			▨	▨								▨
PT Crowd	20-70 15" Hg			▨	▨	▨							▨
	10" Hg			▨	▨	▨							▨
	5" Hg			▨	▨	▨							▨
PT Tip In From 20 mph	1			▨	▨	▨							▨
	2			▨	▨	▨							▨
From 30 mph	1			▨	▨	▨							▨
	2			▨	▨	▨							▨
Accel. Time 0-70 mph			sec.	▨	▨	▨		▨	▨	▨	▨	▨	▨
Decel Time 70-30 mph			sec.	▨	▨	▨	▨	▨	▨	▨	▨		▨
Soak	Number of Start Attempts______ Total cranking time		sec.	▨	▨	▨	▨		▨	▨	▨	▨	▨
Idle	Neutral	RPM	Hg						▨	▨	▨	▨	▨
	Drive	RPM	Hg										

*T-Trace, M-Moderate
H-Heavy

AUTOMOTIVE TESTING LABORATORIES, INC.
19900 E. Colfax Ave., Aurora, Colorado 80011
Form EV-0173

FIGURE 5

APPENDIX 3

IDLE TEST PROCEDURES
FOR
INSPECTORS AND MECHANICS
AT
PARTICIPATING GARAGES

July 20, 1973

prepared by

AUTOMOTIVE TESTING LABORATORIES, INC.
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1. INTRODUCTION

You have been selected to participate in a unique study program in the State of Colorado. You have been requested to assist the Colorado Health Department in solving an extremely difficult problem in the State. In order that you may develop an appreciation for what we are are jointly trying to accomplish we would like to introduce you to some of the details of the study program.

As you know, the State of Colorado is plagued with an air pollution problem which is continually worsening. Although this problem has been created by the discharge of pollution from a great many sources, we know that the main contribution is from motor vehicles. Simply resulting from the substantial number in operation, light duty vehicles, that is, passenger cars and light trucks, are the major offenders.

In recognition of this, the Colorado Legislature appropriated funds to evaluate ways to reduce pollution from motor vehicles. The Health Department is conducting an emission testing program involving 300 vehicles from model-years 1964 through 1973. These vehicles will be selected to represent about 90% of the cars registered in the State. All of them will be privately owned. Although there are many aspects to the program, the primary consideration is to evaluate emission inspection at idle.

As you know, the State of Colorado has an existing vehicle inspection program, safety inspection. In view of the fact that the safety inspection program is already established, it is likely that emission inspection will be combined with safety inspection. This appears to be a logical approach. However, the effectiveness of such an approach is as yet unknown. This is precisely what we jointly will be trying to establish, the effectiveness of emission inspection integrated with the existing safety inspection program.

2. DESIGN OF THE PROGRAM

A sample of 300 cars will be selected and scheduled for tests and maintenance over a period of about three and one-half months. About 5 cars will be tested each day. Laboratory emission tests will be performed. Emission inspection at idle will also be performed by laboratory personnel. When this sequence is completed vehicles will be delivered to selected licensed safety inspection stations for emission inspection and maintenance if required. Licensed stations will each receive about 30 vehicles in the three and one-half month period.

Upon delivery to the station, vehicles will be emission tested (inspected) according to the procedures described later in Section 3. A vehicle will either pass or fail depending on its level of emissions. Vehicles which pass the test will be returned to ATL without adjustment or maintenance. Vehicles which fail will be adjusted and /or repaired to the extent necessary to effect a pass. Repairs to failed vehicles will be nominally limited to $50.00 per vehicle for parts and labor at normal garage rates. Vehicles which have been repaired will be re-tested to determine compliance with standards. Vehicles which pass the re-test will be returned to ATL for additional evaluations. Vehicles which fail the re-test will be returned to ATL when $50.00 in repairs have been exhausted.

At this point it should be mentioned that a vehicle which fails to comply with emission standards after incurring the limit of $50.00 probably has a gross malfunction. Gross malfunction could be described as a faulty carburetor, burned valves, worn or damaged rings, etc. If a gross malfunction is indicated, it should be diagnosed and an estimate of repair costs should be prepared and forwarded to ATL.

After the vehicle is returned to ATL, it will be retested. Emission data obtained before and after inspection and maintenance will then be combined with cost data and the effectiveness of the inspection and maintenance procedure will be evaluated.

tions, and ordinances, unless such action will result in continuing compliance with the applicable emission requirements.

3.2.1 Instrumentation

Table 2 lists the recommended equipment required to perform emission-oriented service and repair.

TABLE 2

RECOMMENDED EQUIPMENT
HC and CO Analyzer
Ignition Analyzer, Oscilloscope
Ignition Timing Light
Tachometer
Distributor Advance Tester
Voltmeter, Ammeter, Ohmmeter
Vacuum Gauge, Pressure Gauge
Compression Tester
Dwell Meter

3.2.2 Inspection Procedure

3.2.2.1 Pre-Test

Prepare vehicle and equipment for test.

Test Equipment - Service, warm-up, and calibrate HC/CO test equipment per manufacturers specifications.

Test Vehicle - Verify engine is at normal operating temperature (warm-up as required).

Hook-up - Insert probe in exhaust pipe (driver side if dual exhaust), hook-up tachometer per manufacturers instructions.

3.2.2.2. Test

The inspector will perform HC/CO and rpm measurements and compare HC/CO measurements to Idle Test Standards.

> 2500 rpm - Operate engine in neutral at 2500 rpm; record HC/CO.
>
> Idle rpm- Operate engine at idle rpm (in drive if automatic transmission); record HC/CO and rpm.

NOTE: In a real situation the vehicle owner would be notified of the results of the inspection and would be supplied with a notice of "pass" or "fail". Emission levels would be indicated on the notice. Obviously, if the vehicle passes, no further action is required. If the vehicle fails, the owner retains the option of either having the failure corrected by the inspecting garage or having the failure corrected by another garage of his choosing. In this, the pilot program, the option that might have been selected is not important. We will assume that similar results will be obtained regardless of where a failure is corrected. The emission inspection is now complete. Failed vehicles will be turned over to repair personnel who will perform adjustments and maintenance to a minimum extent to bring the vehicle into compliance. It will be assumed that the repair garage is equipped with acceptable HC/CO instrumentation to evaluate the results of repair efforts. The HC/CO analyzer supplied for inspection should be utilized for diagnosis and repair.

3.2.3. Adjustment and /or Repair

3.2.3.1. Adjustment

Perform engine adjustments for HC/CO. When any adjustment step brings emissions within limits, STOP procedure at that point and re-test per paragraph 3.2.2.

> Rpm - Adjust (if required) to manufacturers specification; re-check HC/CO and record.
>
> HC - Check timing per manufacturers procedure and record. If timing is not within manufacturers tolerance, adjust as required; re-adjust rpm, if required; re-check HC/CO and record.

The Table should be used as an aid in diagnosing the cause for failure. General diagnostic steps are:

Evaluate test results - as provided in this situation by the inspector.

Consult information sources - probable malfunctions table (above), owners vehicle manual, manufacturers manual, automotive shop service manual.

Perform diagnosis - as determined from above information sources and test results, and from the use of test equipment as necessary.

Repair malfunction - remove and replace defective components; adjust as required.

Re-test - as per paragraph 3.2.2.

In diagnosing malfunctions which are indicated by high HC/CO, it is helpful to know the following:

High HC - is normally related to a malfunction in the ignition system or caused by leaking exhaust valves. Ignition system malfunction may be caused by an over-lean fuel mixture such as might be experienced with carburetor unbalance or a leaking intake manifold. A malfunction may also be caused by over-advanced ignition timing, a fouled spark plug, a faulty ignition wire (insulation), or improperly adjusted point dwell.

Ignition mis-fires may be diagnosed by use of an oscilloscope, timing problems by a timing light. Valve failure may be detected by cylinder balance testing and /or compression testing.

High CO - is normally related to an over-rich fuel mixture. This may be caused by a poor idle circuit adjustment, a stuck or partically closed choke, or an abnormally restricted air cleaner. Rough idle may be caused by a clogged PCV valve. Any of these conditions may also cause moderately high HC. In this situation, if CO is reduced, HC will also be reduced.

Figure 1, is a block diagram showing the steps which must be followed to assure compliance with the inspection, adjustment, and repair procedures just described. When the vehicle is delivered to you it will be accompanied by the necessary inspection, adjustment, repair, and estimate forms. We ask that you fill in the required data accurately and completely. The data which you report to us is most important to the success of the project.

APPENDIX 4

VEHICLE ROUTING FORMS

The following forms were all developed after the vehicle flow charts had been constructed. The forms were designed in such a manner that simply filling in the information as it became available would insure that the vehicle had the proper tests performed and that the tests were conducted in the proper order. The routing sheets were attached to a form packet containing the data forms necessary for the indicated test sequence. The form packet then remained with the vehicle until the vehicle was returned to the owner.

ROUTING SHEET

TUNE-UP EVALUATION

VEH.NO.__________

RUN NO. __________

Perform ~~maintenance if~~ required

A/F________ I.RPM________ TIMING________ CHOKE________
Cold Soak
Emission Test No. __________
Driveability Test No. __________

A/F________ I.RPM________ TIMING________ CHOKE________
Cold Soak
Emission Test No. __________
Driveability Test No. __________

A/F________ I.RPM________ TIMING________ CHOKE________
Cold Soak
Emission Test No. __________
Driveability Test No. __________

A/F________ I.RPM________ TIMING________ CHOKE________
Cold Soak
Emission Test No. __________
Driveability Test No. __________

A/F________ I.RPM________ TIMING________ CHOKE________
Cold Soak
Emission Test No. __________
Driveability Test No. __________

A/F________ I.RPM________ TIMING________ CHOKE________
Cold Soak
Emission Test No. __________
Driveability Test No. __________

A/F________ I.RPM________ TIMING________ CHOKE________
Cold Soak
Emission Test No. __________
Driveability Test No. __________

A/F________ I.RPM________ TIMING________ CHOKE________
Cold Soak
Emission Test No. __________
Driveability Test No. __________

TU Eval Proofc ________

Input Punched ________

Input Proofed ________

Input Corrctd ________

out put ________

FIGURE 1

ROUTING SHEET

HIGH ALTITUDE RETROFIT

MANUFACTURER:

TYPE:

Install HAR & Cold Soak

Emission Test NO.

Driveability Test NO.

BASE LINE

Remove HAR

Driveability Test NO.

FIGURE 2

ROUTING SHEET

HIGH ALTITUDE RETROFIT with MAINTENANCE

MANUFACTURER: ______________________________

TYPE: ______________________________

Install HAR, Perform Maintenance & Cold Soak

Emission Test NO. ____________

Driveability Test NO. ____________

BASE LINE

Remove HAR & Cold Soak

Emission Test NO. ____________

Driveability Test NO. ____________

Maintenance Required

Points/Condenser ____________
Distributer cap ____________
Ignition Wires ____________
Air pump ____________
Idle RPM ____________
Timing ____________
Dwell ____________
PCV ____________
Air Cleaner ____________
Choke ____________
Idle CO ____________
Misfire ____________
NO_x Control ____________

FIGURE 3

ROUTING SHEET

SEA LEVEL and HIGH ALTITUDE RETROFITS

SEA LEVEL

MANUFACTURER: CIG COL DAN ECH NLP PSC STP UOP

TYPE: A.BLD A.BLD+EGR A.BLD+VSAD CAT EGR EGR+VSAD N.GAS PROP

Install SLR, Perform any required Maintenance & Cold Soak

Emission Test No. ____________

Driveability Test No. ____________

BASE LINE

Remove SLR & Cold Soak

Emission Test No. ____________

Driveability Test No. ____________

HIGH ALTITUDE

MANUFACTURER: ____________________________

TYPE: ____________________________

Install HAR & Cold Soak

Emission Test No. ____________

Driveability Test No. ____________

Remove HAR

Maintenance Required

Points/Condenser ____________
Distributer cap ____________
Ignition Wires ____________
Air pump ____________
Idle RPM ____________
Timing ____________
Dwell ____________
PCV ____________
Air Cleaner ____________
Choke ____________
Idle CO ____________
Misfire ____________
NO_x Control ____________

FIGURE 4

ROUTING SHEET

VEH.NO. ____________

SEA LEVEL RETROFIT

MANUFACTURER: CIG COL DAN ECH NLP PSC STP UOP

TYPE: A.BLD A.BLD+EGR A.BLD+VSAD CAT EGR EGR+VSAD N.GAS PROP

Install SLR & Cold Soak

Emission Test No. ____________

Driveability Test No. ____________

BASE LINE

Remove SLR

Driveability Test No. ____________

Routing Proofed ________
Input Punched ________
Input Proofed ________
Input Corrected ________
Output ________

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FIGURE 5

ROUTING SHEET

VEH.NO. ____________

SEA LEVEL RETROFIT with MAINTENANCE

MANUFACTURER: CIG COL DAN ECH HLP PSC STP UOP

TYPE: A.BLD A.BLD+EGR A.BLD+VSAD CAT EGR EGR+VSAD N.GAS PROP

Install SLR, Perform Maintenance & Cold Soak

Emission Test No. ____________

Driveability Test No. ____________

BASE LINE

Remove SLR & Cold Soak

Emission Test No. ____________

Driveability Test No. ____________

Maintenance Required

Points/Condenser ________
Distributer cap ________
Ignition Wires ________
Air pump ________
Idle RPM ________
Timing ________
Dwell ________
PCV ________
Air Cleaner ________
Choke ________
Idle CO ________
Misfire ________
NO_x Control ________

Routing Proofed ________
Input Punched ________
Input Proofed ________
Input Corrected ________
Output ________

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FIGURE 6

PROOF393
DATA EDIT PROGRAM

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```
10 DIM K$(18),C(18,12),D(10,21),I(20),E(6,5),B(3,2),K(3,5)
20 DIM S(4,2), T$(16), W$(20), R$(20)
95 REM***********POSSIBLE MAKES***************
100 DATA 'BUIC','CADI','CHEV','OLDS','PONT','FORD','GARB','MERC'
105 DATA 'CHRY','DODG'
110 DATA 'GARB','PLYM','AMMO','DATS','TOYO','VOLK','OPEL','VOLV'
115 REM**********POSSIBLE CID BY MAKE**********
120 DATA 350,430,300,340,401,425,0,472,429,0
130 DATA 140,250,307,350,400,230,327,396,283,194,164,0
140 DATA 350,455,330,425,0,400,350,326,389,421,0
150 DATA 98,200,302,351,400,170,250,289,390,240,352,0,0,302,351,289
155 DATA 190,0
160 DATA 360,383,361,0,198,318,383,170,273,225,0,0
170 DATA 198,318,400,383,273,170,225,0,304,290,232,0,97,0
180 DATA 120,71,116,0,97,102,91,78,73,0,116,0,121,0
185 REM*********POSSIBLE CID BY YEAR*******
190 DATA 97,98,102,116,120,140,198,200,250,302,304,307,318,350,351
195 DATA 360,400,472,0
200 DATA 97,98,102,116,120,140,170,198,250,302,304,307,318,350,351
205 DATA 360,400,472,0
210 DATA 71,97,98,116,121,140,170,198,250,302,304,307,318,350,351,383
215 DATA 400,472,0
220 DATA 71,97,170,198,200,230,250,302,304,307,318,350,351,383,400
225 DATA 455,472,0
230 DATA 91,116,170,200,230,250,290,302,307,318,327,350,351,383,400
235 DATA 430,455,472,0
240 DATA 91,116,200,230,273,289,290,302,307,318,327,350,383,390,396
245 DATA 400,430,455,472,0
250 DATA 91,170,200,230,250,273,283,289,290,300,318,326,327,330,340
255 DATA 383,390,400,425,429,0
260 DATA 78,194,200,230,232,326,273,283,289,318,327,330,340,352
265 DATA 389,383,390,401,425,429,0
270 DATA 73,164,200,225,230,232,283,289,300,318,326,327,330,383,389
275 DATA 390,396,401,425,429,0
280 DATA 73,170,194,200,230,232,283,289,318,327,330,361,389,390
285 DATA 421,425,429,0
287 REM*******IN.WT.-HP COMBINATIONS********
290 DATA 2000,8.3,2250,8.8,2500,9.4,2750,9.9,3000,10.3,3500,11.2
300 DATA 4000,12,4500,12.7,5000,13.4,5500,13.9
305 REM******POSSIBLE SLR MANUFACTURERS******
310 DATA "CIG","COL","DAN","ECH","NLP","PSC","STP","UOP","CMP","0"
315 REM**********POSSIBLE SLR TYPES********
320 DATA "A.BLD","A.BLD+EGR","A.BLD+VSAD","CAT","EGR","EGR+VSAD"
330 DATA "N.GAS","PROP","FBPR","0"
335 REM*******POSSIBLE HAR MANUFACTURERS************
340 DATA "FORD","GM","CHRY","AMMO","0"
345 REM*******POSSIBLE HAR TYPES********************
350 DATA "FORD","GM","CHRY","AMMO","0"
400 PRINT "FILE NAME";
410 INPUT G$
420 OPEN 1,G$,INPUT
500 FOR X= 1 TO 18
510 READ K$(X)
520 NEXT X
530 FOR X= 1 TO 18
540 FOR Y = 1 TO 12
550 READ C(X,Y)
560 IF C(X,Y)= 0 THEN 580
570 NEXT Y
580 NEXT X
590 FOR X= 1 TO 10
600 FOR Y= 1 TO 21
610 READ D(X,Y)
```

```
620 IF D(X,Y)=0 THEN 640
630 NEXT Y
640 NEXT X
650 FOR X= 1 TO 20
660 READ I(X)
670 NEXT X
680 FOR X= 1 TO 10
690 READ V$(X)
700 IF V$(X)="0" THEN 720
710 NEXT X
720 FOR X= 1 TO 10
730 READ R$(X)
740 IF R$(X)="0" THEN 760
750 NEXT X
760 FOR X=11 TO 20
770 READ V$(X)
780 IF V$(X)="0" THEN 800
790 NEXT X
800 FOR X=11 TO 20
810 READ R$(X)
820 IF R$(X)="0" THEN 900
830 NEXT X
900 PRINT
905 ON EOF 1 GOTO 90000
910 PRINT "********"
1000 REM *** GET VEHICLE INFORMATION ***
1010 GO SUB 60000
1015 PRINT USING 20070, V1;
1020 IF T1 < 1 THEN 2032
2030 IF T1 < 9 THEN 2040
2032 PRINT ",TST SEQ.";
2035 GO TO 90000
2040 IF Y1 < 64 THEN 2052
2050 IF Y1 < 74 THEN 2060
2052 PRINT "YEAR";
2054 GOTO 90000
2060 FOR M1= 1 TO 18
2070 IF K$ = K$(M1) THEN 2100
2080 NEXT M1
2090 PRINT ",MAKE";
2100 IF C1> (74-Y1) * 15000 THEN 2130
2110 IF C1< (74-Y1) * 6000 THEN 2130
2120 GO TO 2140
2130 PRINT ",ODOM";
2140 GO TO 2170,2200,2230 ON C1/2-1
2150 PRINT ",CYL";
2160 GO TO 2240
2170 IF C2< 71 THEN 2150
2180 IF C2> 140 THEN 2150
2190 GO TO 2240
2200 IF C2< 164 THEN 2150
2210 IF C2> 250 THEN 2150
2220 GO TO 2240
2230 IF C2< 260 THEN 2150
2235 IF C2 > 472 THEN 2150
2240  GO TO 2260,2260,2260,2250,2260, ON R1+1
2250 PRINT ",CARB";
2260 GO TO 2280,2270,2280,2280, ON T2
2270 PRINT ",TRAN";
2280 FOR X= 1 TO 11
2290 IF C(M1,X)=0 THEN 2320
2300 IF C(M1,X)=C2 THEN 2340
2310 NEXT X
2320 PRINT ",CID";
2325 GO TO 2400
2340 Y= 74-Y1
2350 FOR X=1 TO 20
2360 IF D(Y,X)= 0 THEN 2390
```

```
2370 IF D(Y,X) = C2 THEN 2400
2380 NEXT X
2390 PRINT ",CID";
2400 FOR X = 1 TO 20 STEP 2
2410 IF I1=I(X) THEN 2450
2420 NEXT X
2430 PRINT ",I.VT/HP";
2440 GO TO 2460
2450 IF H1<>I(X+1) THEN 2430
2460 IF E$= "YES" THEN 2490
2470 IF E$= "NO" THEN 2490
2480 PRINT ",EMC";
2490 IF V$= "YES" THEN 2520
2500 IF V$= "NO" THEN 2520
2510 PRINT ",EVC";
2520 IF P$= "YES" THEN 2543
2530 IF P$= "NO" THEN 2543
2540 PRINT ",PCV";
2543 IF T1<>8 THEN 2550
2545 T1=4
2547 GOTO 3000
2550 REM **** GET EMISSION DATA ****
2555 PR.
2560 GET T$
2580 REM ***** CHECK 1ST EMISSION TEST ****
2590 PRINT USING 80000,T$;
2595 GOSUB 61000
2700 GOSUB 62000
2710 GET S$
2715 E2=1
2717 #$=S$
2720 IF S$=T$ THEN 2770
2730 REM **** CHECK 2ND EMISSION TEST ****
2740 PRINT
2750 PRINT USING 80000, S$;
2755 GOSUB 61000
2760 GOSUB 62000
2762 GET S$
2765 E2=2
2770 REM **** CHECK 1ST MAINTENANCE STATUS ****
2780 PRINT
2790 PRINT "1ST MTCE";
2800 IF S$=T$ THEN 2820
2810 PRINT ",TEST#";
2820 REM  VEH#  DATE
2830 GET  V2,  D$
2840 IF V2=V1 THEN 2860
2850 PRINT ",VEH#";
2860 REM *** CHECK MTCE DATA ****
2870 GOSUB 63000
2880 IF E2=1 THEN 2930
2890 REM *** CHECK 2ND MTCE STATUS ****
2900 PRINT
2910 PRINT "2ND MTCE";
2920 GOSUB 63000
2930 REM **** CHECK INSPECTION STATION DATA ****
2940 PRINT
2950 PRINT "INSP.";
2960 GET V2
2970 IF V2=V1 THEN 2990
2980 PRINT ",VEH#";
2990 GOSUB 64000
3000 GOTO 3020,3100,3400,3400,3800,4100,4100, ON T1
3010 PAUSE
3020 PRINT
3030 PRINT "******"
3040 GOTO 1000
3100 REM *** TUNE UP SEQUENCE ***
```

```
3110 PRINT
3120 PRINT "TU";
3130 GET V2
3140 IF V2=V1 THEN 3152
3150 PRINT "VEH#";
3152 GET R7
3153 IF R7>25 THEN 3157
3155 IF R7> 0 THEN 3160
3157 PRINT ",RUN#";
3160 FOR X=2 TO 16 STEP 2
3170 GET T$(X-1), T$(X)
3180 IF T$ (X) = T$(X-1) THEN 3200
3190 PRINT USING 80050, X/2;
3200 NEXT X
3210 FOR Z = 2 TO 16 STEP 2
3220 GET S$
3230 PRINT
3240 PRINT USING 80000, S$;
3250 IF S$= T$(Z-1) THEN 3270
3260 PRINT ",TST#";
3270 REM **** CHECK EMISSION & DRIVEABILITY DATA ***
3275 GOSUB 61000
3280 GOSUB 62000
3300 GOSUB 65000
3310 NEXT Z
3320 GOTO 3020
3400 REM **** RETROFIT WITH MTCE SEQUENCE ****
3410 PRINT
3420 GO TO 3440,3460  ON T1-2
3430 PAUSE
3440 PRINT "HAR";
3445 X1=10
3450 GO TO 3470
3460 PRINT "SLR";
3465 X1=0
3470 REM **** CHECK TYPE & MANUF ***
3480 GOSUB 66000
3570 FOR X = 2 TO 4 STEP 2
3580 GET T$(X-1), T$(X)
3590 IF T$(X-1) = T$(X) THEN 3610
3600 PRINT USING 80050,X/2;
3610 NEXT X
3620 REM **** CHECK EMISSION & DRIVEABILITY ***
3630 FOR Z=2 TO 4 STEP 2
3640 GET S$
3650 PRINT
3660 PRINT USING 80000,S$;
3670 IF S$= T$(Z-1) THEN 3690
3680 PRINT ",TST#";
3690 GOSUB 61000
3695 GOSUB 62000
3700 GOSUB 65000
3710 NEXT Z
3720 GOTO 3020
3800 REM *** COMBINATION RETROFIT SEQUENCE *****
3810 PRINT
3820 PRINT "SLR";
3830 X1=0
3840 REM *** CHECK SLR TYPE & MANUF ***
3850 GOSUB 66000
3860 FOR X = 2 TO 4 STEP 2
3870 GET T$ (X-1), T$(Y)
3880 IF T$(X-1) = T$(X) THEN 3890
3885 PRINT USING 80050,X/2;
3890 NEXT X
3891 PRINT
3892 PRINT "HAR";
3893 REM **** CHECK HAR TYPE & MANUF *****
```

```
3894 X1=10
3895 GOSUB 66000
3896 GET T$(5), T$(6)
3897 IF T$ (5) = T$(6) THEN 3910
3898 PRINT USING 80050,1;
3910 REM **** CHECK EMISSION & DRIVEABILITY ****
3920 FOR Z= 2 TO 6 STEP 2
3930 PRINT
3940 GET S$
3950 PRINT USING 80000,S$;
3960 IF T$(Z-1) = S$ THEN 3980
3970 PRINT ",TST#";
3980 GOSUB 61000
3985 GOSUB 62000
3990 GOSUB 65000
4000 NEXT Z
4010 GOTO 3020
4100 REM **** RETROFIT (NO MTCE) SEQUENCE *****
4110 PRINT
4120 GO TO 4140,4170, ON T1-5
4130 PAUSE
4140 X1=10
4150 PRINT "HAR";
4160 GO TO 4190
4170 X1=0
4180 PRINT "SLR";
4190 REM *** CHECK TYPE & MANUF ***
4200 GOSUB 66000
4300 REM **** CHECK ROUTING ****
4310 GET T$(1), T$(2)
4320 IF T$(1) = T$(2) THEN 4340
4330 PRINT USING 80050,1;
4340 GET T$(3)
4370 IF T$(3) = #$ THEN 4410
4380 PRINT USING 80050,3;
4390 GO TO 4410
4400 IF T$(3) <>S$ THEN 4380
4410 REM *** CHECK EMISSION & DRIVEABILITY ****
4420 PRINT
4430 GET S$
4440 PRINT USING 80000,S$;
4450 IF S$ = T$(1) THEN 4470
4460 PRINT ",TST#";
4470 GOSUB 61000
4480 GOSUB 62000
4490 Z=2
4500 GOSUB 65000
4510 Z=3
4520 PRINT
4530 PRINT "B.LINE";
4540 GOSUB 65000
4550 GOTO 3020
60000 REM *** VEHICLE INFO SUBROUTINE ***
60010 REM *** TEST SEQ. VEH# YR MK MODL ODOM CYL CID BBL
60020 GET T1, V1, Y1, K$, M$, O1, C1, C2, B1
60030 REM ***
60040 REM *** TRN   IN.WT   HP   FMC   EVC   PCV
60050 GET      T2,    I1,    H1,   F$,   V$,   P$
60060 RETURN
61000 REM *** EMISSION DATA GET SUBROUTINE***
61010 REM *** DATE   VEH#   BARO.   D.BULB   W.BULB
61020 GET      D$,    V2,    B2,      T8,      T9
61030 MAT GET E
61040 MAT GET B
61050 MAT GET K
61060 MAT GET 5
61070 RETURN
62000 REM *** EMISSION DATA CHECK SUBROUTINE ****
```

```
62010 IF V2 = V1 THEN 62030
62020 PRINT ",VEH";
62030 IF B2 < 24.3 THEN 62050
62040 IF B2 < 25 THEN 62060
62050 PRINT ",BAR.";
62060 IF T8>86 THEN 62080
62070 IF T8>=68 THEN 62090
62080 PRINT ",DB";
62090 IF T9>T8 THEN 62110
62100 IF T9>T8-25 THEN 62120
62110 PRINT ",WB";
62120 FOR X = 1 TO 6
62130 IF E(X,1) < 200 THEN 62150
62140 IF E(X,1)< 500 THEN 62160
62150 PRINT ",EHC";
62160 IF E(X,2) < 100 THEN 62180
62170 IF E(X,2)< 700 THEN 62190
62180 PRINT ",ECO";
62190 IF E(X,3)< 100 THEN 62210
62200 IF E(X,3)< 400 THEN 62220
62210 PRINT ",ECO2";
62220 IF E(X,4)< 500 THEN 62240
62230 IF E(X,4) < 900 THEN 62250
62240 PRINT ",ENOX";
62250 IF E(X,5) < 100 THEN 62270
62260 IF E(X,5) < 400  THEN 62280
62270 PRINT ",ELHC";
62280 NEXT X
62290 FOR X = 1 TO 5
62300 FOR Y = 2 TO 6 STEP 2
62310 IF E(Y,X)>=E(Y-1,X) THEN 62325
62320 PRINT ",BKGD";
62325 NEXT Y
62330 NEXT X
62340 FOR X = 1 TO 3
62342 IF X<>2 THEN 62374
62350 IF B(X,1)> 26300 THEN 62370
62360 IF B(X,1)> 25700 THEN 62380
62370 PRINT ",REV";
62372 GO TO 62380
62374 IF B(X,1)> 9800 THEN 62370
62376 IF B(X,1)< 9400 THEN 62370
62380 IF B(X,2)> 11.2 THEN 62400
62390 IF B(X,2)> 10.8 THEN 62410
62400 PRINT ",PRES";
62410 NEXT X
62420 FOR X= 1 TO 3
62430 IF K(X,1) < 200 THEN 62450
62440 IF K(X,1)< 500 THEN 62460
62450 PRINT ",KHC";
62460 IF K(X,2)<100 THEN 62480
62470 IF K(X,2)< 700 THEN 62490
62480 PRINT ",KCO";
62490 IF K(X,3)< 100 THEN 62510
62500 IF K(X,3)< 400 THEN 62520
62510 PRINT ",KCO2";
62520 IF K(X,4)< 500 THEN 62540
62530 IF K(X,4)< 900 THEN 62550
62540 PRINT ",KNOX";
62550 IF K(X,5)< 100 THEN 62570
62560 IF K(X,5)< 400 THEN 62580
62565 IF K(X,5)=2500 THEN 62580
62570 PRINT ",KLHC";
62580 NEXT X
62590 FOR X = 1 TO 4
62600 IF S(X,1)< 50 THEN 62620
62605 IF S(X,1) < 2001 THEN 62630
62610 IF S(X,1) =2500 THEN 62630
```

```
62620 PRINT ",SHC";
62630 IF S(X,2)<.2 THEN 62660
62640 IF S(X,2)<10.1 THEN 62670
62650 IF S(X,2) = 20 THEN 62670
62660 PRINT ",SCO";
62670 NEXT X
62680 RETURN
63000 REM **** MTCE DATA CHECK SUBROUTINE ****
63010 REM   AP    RPM    TIM    DWELL    PCV
63020 GET   A$,   RO,    TO,    DO,      P$
63030 REM   A.CL.    CHOKE    I.CO    MISFIRE    NOX
63040 GET   C$,      C$,      IO,     F$,        N$
63050 IF A$ ="YES" THEN 63090
63060 IF A$ ="NA" THEN 63090
63070 IF A$="NO" THEN 63090
63080 PRINT ",A.PMP";
63090 IF ABS(RO)< 500 THEN 63110
63100 PRINT ",I.RPM";
63110 IF ABS(TO) < 15 THEN 63130
63120 PRINT ",TIM";
63130 IF ABS(DO) < 20 THEN 63150
63140 PRINT ",DWL";
63150 IF P$ = "NA" THEN 63190
63160 IF P$ = "YES" THEN 63190
63170 IF P$ = "NO" THEN 63190
63180 PRINT ",PCV";
63190 IF C$ = "YES" THEN 63220
63200 IF C$ = "NO" THEN 63220
63210 PRINT ",A.CL";
63220 IF IO < .1 THEN 63240
63230 IF IO < 12 THEN 63242
63240 PRINT ",I.CO";
63242 IF C$="YES" THEN 63250
63244 IF C$="NO" THEN 63250
63246 IF C$="NA" THEN 63250
63248 PRINT ",CHOKE";
63250 IF F$= "NO" THEN 63280
63260 IF F$ = "YES" THEN 63280
63270 PRINT ",M.FIRE";
63280 IF N$ = "NA" THEN 63320
63290 IF N$ = "YES" THEN 63320
63300 IF N$ = "NO" THEN 63320
63310 PRINT ",N.CTRL";
63320 RETURN
64000 REM *** INSPECTION STATION DATA CHECK ****
64010 FOR X = 1 TO 5
64020 FOR Y = 1 TO 2
64030 GET H5
64040 IF H5> 2000 THEN 64080
64050 IF H5>50 THEN 64090
64060 IF H5 = 0 THEN 64090
64065 PRINT USING 80010,X;
64070 GOTO 64090
64080 IF H5<>2500 THEN 64065
64090 NEXT Y
64100 REM *** CHECK FAILURE CODE ****
64110 GOSUB 64400
64120 FOR Y= 1 TO 2
64130 GET C5
64140 IF C5>10 THEN 64190
64150 IF C5>.2 THEN 64200
64160 IF C5=0 THEN 64200
64170 PRINT USING 80020,X;
64180 GOTO 64200
64190 IF C5<>20      64170
64200 NEXT Y
64210 REM *** CHECK FAILURE CODE ***
64220 GOSUB 64400
```

```
64230 GET M5
64240 IF M5 < 0 THEN 64260
64250 IF M5 < 11 THEN 64270
64260 PRINT USING 80040,X;
64270 IF X<> 4 THEN 64320
64280 GET M5
64290 IF M5<0 THEN 64310
64300 IF M5<35 THEN 64320
64310 PRINT ",COSTR";
64320 NEXT X
64330 RETURN
64400 REM *** FAILURE CODE CHECK SUBROUTINE ****
64410 GET H$
64420 IF H$ = "FAIL" THEN 64460
64430 IF H$ = "PASS" THEN 64460
64440 IF H$ = "0" THEN 64460
64450 PRINT USING 80030,X;
64460 RETURN
65000 REM **** DRIVEABILITY CHECK SUBROUTINE ****
65010 REM   VEH#    TEST#    DEMERITS
65020 GET    V2,    S$,    D2
65030 IF V2 = V1 THEN 65050
65040 PRINT ",DVEH#";
65050 IF S$ = T$(Z) THEN 65070
65060 PRINT ",DTST#";
65070 IF D2<0 THEN 65090
65080 IF D2<125 THEN 65100
65090 PRINT ",DEM.";
65100 RETURN
66000 REM *** RETROFIT  TYPE & MANUF. CHECK SUBROUTINE ****
66005 GET W$
66010 FOR X= 1 TO 10
66030 IF W$ = W$(X+X1) THEN 66060
66040 NEXT X
66050 PRINT ",MANF";
66060 GET R$
66070 FOR X=1 TO 10
66080 IF R$ = R$(X+X1) THEN 66110
66090 NEXT X
66100 PRINT ",TYPE";
66110 RETURN
80000 :EM.TST:#####
80010 :,HC#
80020 :,CC#
80030 :,FAIL#
80040 :,COST#
80050 :,HT#
80060 :#
80070 :0&&
90000 END
```

SAMPLE RUN

DATA EDIT PROGRAM

```
RUN PROCF393

PROCF393    13:12   12/03/73  MONDAY     IC4

FILE NAME? V141T147

*******
141,CDCM
EM.TST:C0328
1ST MTCE
INSP.
******
143,CDCM
EM.TST:C0340
1ST MTCE
INSP.
SLR
EM.TST:C0383,BKGD
EM.TST:C0409
******
144
EM.TST:C0342
EM.TST:C0353,SHC
1ST MTCE
2ND MTCE
INSP.,HC1,HC2,HC3,HC5
SLR
HAR
EM.TST:C0420
EM.TST:C0393,BKGD
EM.TST:C0406
******
145,CDCM
EM.TST:C0343
1ST MTCE
INSP.,C01,C05
HAR
EM.TST:C0376,WB
B.LINE
******
147,CDCM
EM.TST:C0345
EM.TST:C0379,WB,BKGD
1ST MTCE
2ND MTCE
INSP.
TU
EM.TST:C0386,BKGD
EM.TST:C0402
EM.TST:C0421
EM.TST:CA433,REV,SCC
EM.TST:C0448,SCC
EM.TST:C0462,BAR.,REV,SCC
EM.TST:C0471,SCC,SHC
EM.TST:C0493
******
```

SEA LEVEL RETROFIT EVALUATION VEHICLES

VEH	YEAR	MAKE	MODEL	CID	CYL	CARB	TRAN	I.WT	ODOM.	RETROFIT TYPE	INSTALLED COST
015	1967	FORD	STAW	289	8	2	3	3500	060240	EGR+VSAD	25.00
017	1966	CHEV	BISC	283	8	2	A	4000	051045	EGR+VSAD	25.00
021	1967	PLYM	BELV	273	8	2	A	3500	070009	EGR+VSAD	25.00
025	1966	DODG	VAN	273	8	2	3	3500	054740	EGR+VSAD	25.00
028	1964	OLDS	STAW	330	8	2	A	4000	089020	EGR+VSAD	25.00
029	1965	PONT	TEMP	326	8	2	A	3500	059585	EGR+VSAD	25.00
035	1965	DODG	POLA	383	8	2	A	4000	064463	EGR+VSAD	25.00
037	1964	FORD	FAIR	289	8	2	3	3500	052629	EGR+VSAD	25.00
040	1968	FORD	CUST	302	8	2	A	4000	019445	A.BLD	25.00
041	1970	CHEV	NOVA	230	6	2	A	3000	030980	A.BLD	25.00
042	1969	PLYM	BELV	318	8	2	A	3500	039269	A.BLD	25.00
043	1971	FORD	MAVE	170	6	2	3	2750	020583	A.BLD	25.00
045	1972	DODG	DART	225	6	1	A	3000	005414	A.BLD	25.00
098	1972	FORD	MAVE	302	8	2	A	3000	026575	CATALYTIC	155.00
099	1971	CHEV	BLAZ	350	8	4	4	4000	019987	CATALYTIC	155.00
100	1969	FORD	MUST	302	8	2	A	3000	047190	CATALYTIC	155.00
104	1968	PLYM	BELV	273	8	2	A	3500	058630	CATALYTIC	155.00
138	1973	DODG	TRUC	360	8	2	A	4000	001000	PROPANE	650.00
139	1970	FORD	TORI	250	6	1	3	3500	031895	A.BLD+EGR	36.95
140	1966	OLDS	DYNA	425	8	2	A	4500	048553	A.BLD+EGR	36.95
143	1966	FORD	MUST	289	8	2	A	3000	038659	A.BLD+EGR	36.95
144	1972	FORD	GALA	400	8	2	A	4000	012721	EGR	32.15
146	1969	OLDS	DELT	455	8	2	A	4000	061594	A.BLD+EGR	36.95
148	1972	PLYM	SATE	400	8	2	A	3500	014660	A.BLD+EGR	36.95
150	1971	DODG	DART	318	8	2	A	3000	026700	EGR	32.15
152	1971	FORD	GALA	351	8	2	A	4000	029562	A.BLD+EGR	36.95
153	1965	CHEV	BELA	283	8	2	A	4000	130460	A.BLD+EGR	36.95
155	1968	CHEV	BELA	307	8	2	A	4000	066417	EGR	32.15
156	1971	VOLK	SEDA	97	4	1	4	2000	024425	EGR	32.15
166	1970	VOLK	SEDA	97	4	1	4	2000	012474	EGR	32.15
169	1965	PLYM	FURY	318	8	2	A	4000	113497	A.BLD+EGR	36.95
171	1965	FORD	STAW	289	8	2	A	4500	071092	A.BLD+EGR	36.95
172	1964	CHEV	IMPA	283	8	2	A	3500	110629	A.BLD+EGR	36.95
178	1964	FORD	GALA	390	8	4	A	4000	059024	A.BLD+EGR	36.95
215	1972	FORD	TRUC	360	8	2	A	5000	019696	PROPANE	650.00
216	1969	CHEV	IMPA	350	8	4	A	4000	021573	PROPANE	650.00
242	1970	FORD	MUST	302	8	2	A	3500	016785	FBPR	24.10
248	1969	PONT	LEMA	350	8	2	A	4000	027997	FBPR	24.10
249	1971	PLYM	FURY	383	8	4	A	4000	030259	FBPR	24.10
255	1972	CHEV	NOVA	307	8	2	A	3000	032867	FBPR	24.10
265	1969	CHEV	CAPR	327	8	4	A	4000	030213	A.BLD	24.95
267	1967	FORD	FALC	200	6	1	3	2750	103550	A.BLD+VSAD	24.95
271	1967	PONT	FIRE	326	8	4	A	3500	059028	A.BLD+VSAD	24.95
272	1966	PLYM	FURY	318	8	2	A	4000	092494	A.BLD+VSAD	24.95
276	1966	PONT	LEMA	326	8	4	A	3500	073426	A.BLD+VSAD	24.95
280	1967	CHEV	STAW	327	8	4	3	4000	096491	A.BLD+VSAD	24.95
283	1968	PONT	CATA	400	8	4	A	4500	075255	FBPR	24.10

SEA LEVEL RETROFIT EVALUATION

EXHAUST EMISSIONS BEFORE INSTALLATION

1975 FEDERAL TEST PROCEDURE

	# OF	HC		CO		NOX		MPG		DEMERITS	
	VEH.	MEAN	S.D.	MEAN	S.D.	MEAN	S.D.	MEAN	S.D.	MEAN	S.D.
*1964 - 1967 VEHICLES											
VSAD & A.BLD	5	7.71	3.4	120.3	45.7	2.55	1.4	15.0	4.0	20.4	18.8
VSAD & EGR	8	9.84	3.2	154.7	28.6	1.21	0.6	13.9	1.5	48.2	38.3
EGR & A.BLD	7	11.17	2.6	158.9	44.9	1.98	1.2	12.7	1.5	13.1	8.1
*1968 - 1972 VEHICLES											
CATALYTIC	4	5.55	0.8	80.9	38.9	2.13	0.9	14.3	0.6	49.2	58.3
LPG CONVERSION	3	6.93	1.0	95.3	52.0	4.05	1.4	11.8	0.5	44.3	37.6
A.BLD	6	4.18	0.5	62.5	16.9	3.06	0.4	17.2	3.2	42.0	29.3
EGR	5	5.08	1.5	81.9	19.4	2.75	1.1	17.2	4.3	8.6	7.8
EGR & A.BLD	4	4.84	0.7	95.6	34.8	2.73	1.2	13.3	2.0	8.0	4.8
FBPR	5	5.36	0.7	102.7	55.1	2.52	1.4	13.0	2.4	12.0	11.7

EXHAUST EMISSIONS AFTER INSTALLATION

1975 FEDERAL TEST PROCEDURE

	# OF	HC		CO		NOX		MPG		DEMERITS	
	VEH.	MEAN	S.D.	MEAN	S.D.	MEAN	S.D.	MEAN	S.D.	MEAN	S.D.
*1964 - 1967 VEHICLES											
VSAD & A.BLD	5	6.27	2.7	110.0	49.0	1.35	0.5	13.8	4.2	17.2	15.6
VSAD & EGR	8	7.27	1.5	137.4	26.3	0.88	0.4	13.9	1.5	56.9	35.5
EGR & A.BLD	7	8.67	2.4	123.7	47.5	1.46	0.8	13.0	1.5	42.9	46.2
*1968 - 1972 VEHICLES											
CATALYTIC	4	1.54	0.3	13.3	16.1	2.19	1.0	14.5	1.4	19.5	22.9
LPG CONVERSION	3	4.12	2.9	44.3	35.0	4.20	1.5	14.3	1.2	1.3	2.3
A.BLD	6	3.45	0.4	36.4	26.0	3.79	0.9	17.0	4.6	48.7	42.8
EGR	5	4.73	1.3	60.6	15.5	1.57	0.4	15.7	3.6	9.2	2.3
EGR & A.BLD	4	4.01	0.5	49.7	15.8	1.94	0.8	13.5	1.8	14.5	9.3
FBPR	5	4.39	0.8	72.2	28.0	3.09	1.6	13.3	1.9	12.6	20.0

SEA LEVEL RETROFIT EVALUATION

EXHAUST EMISSION REDUCTIONS AFTER INSTALLATION

1975 FEDERAL TEST PROCEDURE

	# OF	HC		CO		NOX		MPG		DEMERITS	
	VEH.	MEAN	S.D.	MEAN	S.D.	MEAN	S.D.	MEAN	S.D.	MEAN	S.D.
*1964 - 1967 VEHICLES											
VSAD & A.BLD	5	1.432	1.4	10.28	25.2	1.192	1.1	1.20	1.5	3.20	32.6
VSAD & EGR	8	2.566	2.1	17.27	21.1	0.334	0.3	0.06	0.7	-8.62	31.7
EGR & A.BLD	7	2.506	1.1	33.24	12.5	0.498	0.5	-0.31	1.0	-29.71	43.9
*1968 - 1972 VEHICLES											
CATALYTIC	4	4.013	0.5	67.55	21.3	-0.059	0.2	-0.24	1.1	29.75	38.6
LPG CONVERSION	3	2.806	2.9	51.03	47.2	-0.156	0.6	-2.50	0.7	43.00	39.9
A.BLD	6	0.730	0.3	26.17	15.3	-0.724	0.9	0.15	1.7	-6.67	26.0
EGR	5	0.358	0.5	1.36	10.3	1.177	0.8	1.51	1.0	-0.60	8.8
EGR & A.BLD	4	0.824	0.7	45.82	22.3	0.787	0.4	-0.23	0.4	-6.50	7.6
FBPR	5	0.932	0.5	30.52	41.5	-0.571	0.8	-0.33	0.8	-0.60	9.6

PERCENT REDUCTIONS AND REDUCTIONS PER DOLLAR

1975 FEDERAL TEST PROCEDURE

	# OF	------PERCENT REDUCTIONS------				MILLIGRAMS/MILE/DOLLAR		
	VEH.	HC	CO	NOX	MPG	HC	CO	NOX
*1964 - 1967 VEHICLES								
VSAD & A.BLD	5	18.58	8.55	46.82	8.01	57.4	412.0	47.8
VSAD & EGR	8	26.08	11.16	27.61	0.43	102.7	690.7	13.4
EGR & A.BLD	7	22.43	21.18	25.41	-2.44	67.8	899.6	13.5
*1968 - 1972 VEHICLES								
CATALYTIC	4	72.30	83.51	-2.79	-1.71	25.9	435.8	-0.4
LPG CONVERSION	3	40.50	53.53	-3.84	-21.20	4.3	78.5	-0.2
A.BLD	6	17.48	41.84	-23.65	0.87	29.2	1047.1	-29.0
EGR	5	7.05	2.20	42.84	8.78	11.1	42.4	36.6
EGR & A.BLD	4	17.04	47.95	28.81	-1.70	22.3	1240.1	21.3
FBPR	5	17.96	29.72	-22.63	-2.55	39.9	1266.6	-23.7

APPENDIX 7

STATE OF CALIFORNIA
AIR RESOURCES BOARD

DRIVEABILITY PROCEDURE

Revised 3/30/72

DRIVEABILITY TEST PROCEDURE
(WARM)

The following is the test procedure to be used for vehicle driveability evaluation. Three tests are to be performed by three different drivers as delineated in the test procedure. If a change is made to the vehicle, tests should be run both with and without the change. A level smooth-surface road, free of traffic interference, should be selected for desirable repeatability of the tests.

I. Vehicle Preparation

   a. Install engine tachometer and intake manifold vacuum gauge - warm up vehicle (minimum 5 miles, driving).

   b. Set engine RPM, fuel mixture and distributor timing to manufacturer's specifications.

II. Warm Vehicle Driveability Procedure - (See data sheet)

   *a. Warmup - Warm up vehicle for approximately 10 miles at freeway speeds.

   b. Curb Idle Evaluation - Operate vehicle in neutral (N) for manual transmissions plus drive (D) gear for automatic transmission. Record idle quality, RPM, and vacuum.

   c. Road Load Operations - Operate vehicle at constant speed cruise conditions at 20, 30, 40, 50, 60, and 70 mph. Record drive quality, RPM, and vacuum at each speed mode.

   d. Wide Open Throttle (WOT) Accelerations - With automatic transmission (AT) vehicle, make the slow, moderate, and sudden WOT accelerations from 0 through 30 mph. With manual transmission (MT) vehicles, accelerate in high gear from 20 through 30 mph at WOT for the three throttle opening rates. Record drive mode quality. Be sure that throttle is wide open before reaching 30 mph.

   e. Part Throttle (PT) Accelerations - With automatic transmission vehicle, make accelerations from 0 through 30 mph at 1/4, 1/2 and 3/4 constant throttle positions. With manual transmission vehicle, these PT accelerations are to be made from 20 through 30 mph. Record drive mode quality.

*May omit this step if vehicle was previously warmed up.

f. Partial Throttle Crowd - "Crowds" are evaluated in high gear from 30 through 70 mph. Tests should be made by continually increasing the throttle opening as needed to maintain a constant vacuum for each of the following readings: 15", 10", and 5" Hg. Record drive mode quality.

g. Partial Throttle Tip-in - Evaluate the "tip-in" characteristics by making PT accelerations from 20 and 30 mph. Do not accelerate at a load which will cause the automatic transmission to down-shift. Record drive mode quality.

h. Acceleration Time - Run WOT acceleration from 0 through 70 mph and record time of acceleration.

i. Deceleration Time - Engine coast down conditions are evaluated from 70 mph (stabilized) to 30 mph at closed throttle, record deceleration time. Repeat in the opposite direction to cancel effect of wind.

j. Soak - After the above tests have been completed, perform three consecutive WOT accelerations from 0 through 70 mph and then idle for 30 seconds. Shut off engine and soak for 15 minutes. Check for dieseling. Restart at 1/2 throttle and hold at 1500 rpm for 3 seconds, return to idle, maintain idle for 10 seconds in Neutral for MT and 10 seconds in Drive for AT. Record number of starting attempts, cranking time and idle quality, RPM and vacuum.

k. Repeat tests (a) through (j), above, two additional times using different drivers. Record results on separate data sheets, then average the results.

III. DEFINITIONS OF TERMS APPLICABLE TO ATTACHED DRIVEABILITY PROCEDURE

a. Road Load - A fixed throttle position which maintains a constant vehicle speed on a level road.

b. Coast - Deceleration at closed (curb idle) throttle.

c. Wide Open Throttle (WOT) Acceleration - An acceleration made entirely at wide open throttle (from any speed).

d. Part Throttle (PT) Acceleration - An acceleration made at any fixed throttle position less than WOT.

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e. Tip-in - Vehicle response (up to 2 seconds in duration) to the initial opening of the throttle.

f. Crowd - An acceleration made at a continually increasing throttle opening.

g. Idle Quality - An evaluation of vehicle smoothness, with the engine at the curb idle in drive as judged from the driver's seat.

h. Backfire - An explosion in the induction or exhaust system.

i. Hesitation - A temporary lack of initial response in acceleration rate.

j. Stumble - A short, sharp reduction in acceleration rate.

k. Lean Operation - This condition, depending on its severity, can manifest itself as outlined in the following categories:

(1) Stretchiness - A lack of anticipated response to throttle movement. This may occur on slight throttle movement from road load to during light to moderate accelerations.

(2) Surging - A condition of leanness, resulting short, sharp, fluctuations. These may be cyclic or random and can occur at any speed and/or load.

l. Detonation (autoignition) - a knock or ping which is recurrent or repeatable in terms of audibility.

m. Dieseling - Engine continues to run after ignition turned off.

n. Stall at Start - Engine stops during warm-up or curb idle.

o. Stall, Driving - Engine stops during any driving condition or during 30 mph sudden brake application.

Driveability Evaluation Scale

Demerits and Weighting Factors for Different Malfunctions

Malfunction Rated	Demerits Trace	 Moderate	 Heavy	 Yes	Weighting Factor
Idle Roughness	1	2	3	-	1
Hesitation	1	3	6	-	4
Stretchiness	1	3	6	-	4
Stumble	1	3	6	-	4
Surge	1	2	3	-	3
Stall at Start	-	-	-	6	2
Stall, Driving	-	-	-	6	6
Backfire	1	2	3	-	3
Detonation	1	3	6	-	2
Dieseling	-	-	-	6	1
Starting Time - Time per each Start (Sec. - 2.0) (If value negative - 0 demerits)					1

ALTITUDE RETROFIT EVALUATION VEHICLES

										LABOR	-------COSTS-------		
VEH	YEAR	MAKE	MODEL	CID	CYL	CARB	TRAN	I.WT	ODOM.	HOURS	LABOR	PARTS	TOTAL
070	1972	PONT	CATA	400	8	2	A	4500	016700	1.00	12.00	4.28	16.28
077	1972	CHEV	IMPA	400	8	4	A	4500	027848	1.00	12.00	3.81	15.81
082	1971	PLYM	STAW	383	8	2	A	4000	050843	0.40	4.80	1.75	6.55
091	1973	PONT	LEMA	400	8	2	A	4000	006704	1.00	12.00	4.28	16.28
098	1972	FORD	MAVE	302	8	2	A	3000	026575	1.00	12.00	2.78	14.78
099	1971	CHEV	BLAZ	350	8	4	4	4000	019987	1.00	12.00	3.81	15.81
100	1969	FORD	MUST	302	8	2	A	3000	047190	1.00	12.00	1.85	13.85
101	1969	CHEV	STAW	327	8	2	A	4500	068576	0.80	9.60	4.28	13.88
117	1970	OLDS	CUTL	350	8	2	A	4000	053727	1.00	12.00	4.28	16.28
125	1971	PONT	CATA	400	8	2	A	4500	029602	0.70	8.40	4.28	12.68
133	1970	FORD	TORI	351	8	2	A	3500	045898	1.00	12.00	2.78	14.78
139	1970	FORD	TORI	250	6	1	3	3500	031895	0.30	3.60	0.00	3.60
142	1972	CHEV	NOVA	350	8	2	A	3500	025592	1.00	12.00	4.28	16.28
144	1972	FORD	GALA	400	8	2	A	4000	012721	0.80	9.60	2.78	12.38
145	1973	FORD	MAVE	302	8	2	A	3000	005516	0.80	9.60	2.78	12.38
146	1969	OLDS	DELT	455	8	2	A	4000	061594	0.70	8.40	4.28	12.68
150	1971	DODG	DART	318	8	2	A	3000	026700	1.00	12.00	1.75	13.75
152	1971	FORD	GALA	351	8	2	A	4000	029562	1.00	12.00	2.78	14.78
155	1968	CHEV	BELA	307	8	2	A	4000	066417	0.70	8.40	4.28	12.68
161	1969	MERC	COUG	351	8	2	A	3500	047191	0.70	8.40	1.85	10.25
173	1972	OLDS	CUTL	350	8	2	A	3500	026639	0.70	8.40	4.28	12.68
182	1968	CHEV	CAME	327	8	2	A	3500	083926	0.70	8.40	4.28	12.68
184	1971	CHEV	IMPA	350	8	2	A	4000	035988	0.50	6.00	4.28	10.28
187	1973	FORD	LTD	351	8	2	A	4500	004725	0.50	6.00	2.78	8.78
188	1971	MERC	COUG	351	8	2	A	4000	017215	0.50	6.00	2.78	8.78
194	1968	CHEV	IMPA	327	8	4	A	4000	054000	0.80	9.60	3.81	13.41
195	1973	CHEV	CHEV	350	8	2	A	4000	006886	1.00	12.00	4.28	16.28
196	1971	CHEV	CAPR	400	8	2	A	4500	036250	0.70	8.40	4.28	12.68
200	1972	CHEV	NOVA	307	8	2	A	3500	015710	0.70	8.40	4.28	12.68
204	1970	FORD	GALA	390	8	2	A	4000	020723	1.00	12.00	2.78	14.78
205	1969	CHEV	STAW	350	8	4	A	4500	093878	0.80	9.60	3.81	13.41
211	1970	PLYM	FURY	318	8	2	A	4000	063652	0.80	9.60	1.75	11.35
217	1972	CADI	COUP	472	8	4	A	5000	017251	0.60	7.20	3.81	11.01
218	1973	CHEV	NOVA	307	8	2	A	3500	016372	0.80	9.60	4.28	13.88
220	1968	BUIC	LESA	350	8	4	A	4500	074568	0.50	6.00	3.81	9.81
224	1968	CHEV	MALI	250	6	1	A	3500	043307	0.30	3.60	0.00	3.60
225	1968	CHEV	STAW	396	8	4	A	4500	048577	0.70	8.40	3.81	12.21
226	1973	DODG	DART	318	8	2	A	3000	003813	0.80	9.60	1.75	11.35
227	1973	AMMO	STAW	304	8	2	A	3000	003437	0.80	9.60	2.00	11.60
231	1973	PLYM	DUST	318	8	2	A	3500	007751	0.60	7.20	1.75	8.95
232	1973	FORD	MAVE	200	6	1	3	2500	003468	0.30	3.60	0.00	3.60
233	1972	BUIC	LESA	350	8	4	A	4500	020861	1.00	12.00	3.81	15.81
234	1968	MERC	COUG	302	8	4	A	3500	074758	0.70	8.40	1.85	10.25
237	1968	CADI	FLEE	472	8	4	A	5000	065733	0.80	9.60	3.81	13.41
238	1969	DODG	CORO	318	8	2	A	3500	051016	0.80	9.60	1.75	11.35
242	1970	FORD	MUST	302	8	2	A	3500	016785	0.70	8.40	2.78	11.18
243	1969	PONT	CATA	400	8	2	A	4000	057823	0.70	8.40	4.28	12.68
245	1968	FORD	FAIR	289	8	2	3	3500	077348	0.60	7.20	2.78	9.98
246	1968	OLDS	DELT	455	8	2	A	4500	114750	0.50	6.00	4.28	10.28
247	1968	FORD	GALA	390	8	2	A	4000	046034	0.80	9.60	1.85	11.45

ALTITUDE RETROFIT EVALUATION VEHICLES

										LABOR	-------COSTS-------		
VEH	YEAR	MAKE	MODEL	CID	CYL	CARB	TRAN	I.WT	ODOM.	HOURS	LABOR	PARTS	TOTAL
248	1969	PONT	LEMA	350	8	2	A	4000	027997	0.70	8.40	4.28	12.68
250	1970	CHEV	CAME	350	8	2	4	3500	047370	0.50	6.00	4.28	10.28
251	1973	CHEV	IMPA	350	8	4	A	4000	006702	0.60	7.20	3.81	11.01
252	1973	OLDS	OMEG	350	8	4	3	3500	009599	0.60	7.20	3.81	11.01
254	1970	FORD	MUST	302	8	2	A	3000	036423	0.60	7.20	2.78	9.98
255	1972	CHEV	NOVA	307	8	2	A	3000	032867	0.70	8.40	4.28	12.68
261	1969	FORD	MUST	200	6	1	3	3000	068680	0.40	4.80	0.00	4.80
262	1973	CHEV	STAW	454	8	4	A	4500	017416	0.70	8.40	3.81	12.21
265	1969	CHEV	CAPR	327	8	4	A	4000	030213	0.80	9.60	3.81	13.41
273	1970	CHEV	CAPR	400	8	2	A	4000	047305	1.00	12.00	4.28	16.28
274	1970	BUIC	SKYL	350	8	4	A	4000	034266	0.70	8.40	3.81	12.21
282	1968	FORD	FALC	170	6	1	3	3000	097889	1.00	12.00	1.85	13.85
283	1968	PONT	CATA	400	8	4	A	4500	075255	0.90	10.80	3.81	14.61
284	1971	AMMO	AMBA	401	8	4	A	4000	031837	0.40	4.80	1.40	6.20
285	1968	PLYM	BARR	318	8	2	A	3500	060568	0.80	9.60	1.75	11.35
286	1968	DODG	CHAR	318	8	2	A	3500	065609	0.60	7.20	1.75	8.95
287	1971	BUIC	LESA	455	8	4	A	4500	017998	1.00	12.00	3.81	15.81
288	1968	PONT	TEMP	350	8	2	A	3500	040178	0.80	9.60	4.28	13.88
291	1969	PLYM	FURY	318	8	2	A	4000	052667	0.50	6.00	1.75	7.75
292	1971	CHEV	NOVA	307	8	2	A	3500	029533	0.80	9.60	4.28	13.88
293	1972	FORD	MUST	351	8	4	A	3500	019843	0.20	2.40	0.00	2.40
294	1969	CHRY	NEWP	383	8	2	A	4500	065163	0.60	7.20	1.75	8.95
295	1970	DODG	POLA	383	8	2	A	4500	053254	0.60	7.20	1.75	8.95
297	1971	PLYM	DUST	198	6	1	3	3000	027784	0.40	4.80	1.75	6.55
298	1972	AMMO	JAVE	360	8	4	4	3500	023737	0.60	7.20	2.00	9.20
299	1972	PLYM	SATE	318	8	2	A	3500	028091	0.60	7.20	1.75	8.95
301	1973	MERC	COME	302	8	2	A	3000	010804	0.60	7.20	2.78	9.98
302	1973	BUIC	CENT	350	8	4	A	4000	006508	0.50	6.00	3.81	9.81
303	1973	PLYM	DUST	318	8	2	A	3500	006473	0.40	4.80	1.75	6.55
304	1972	DODG	CORO	318	8	2	A	3500	022983	0.40	4.80	0.00	4.80
305	1969	AMMO	AMBA	290	8	2	A	4000	054001	0.30	3.60	0.00	3.60
306	1969	BUIC	ELEC	430	8	4	A	4500	034898	0.70	8.40	3.81	12.21
307	1969	CHEV	NOVA	230	6	1	A	3000	029124	0.40	4.80	0.00	4.80
308	1969	FORD	TORI	351	8	2	A	3500	021037	0.50	6.00	1.85	7.85
309	1969	FORD	TORI	351	8	2	A	3500	074369	0.70	8.40	1.85	10.25
310	1972	FORD	MAVE	302	8	2	A	3000	008455	0.60	7.20	2.78	9.98
311	1972	FORD	MAVE	250	6	1	A	2750	022036	0.40	4.80	0.00	4.80
312	1972	MERC	COME	302	8	2	A	3000	008589	0.70	8.40	2.78	11.18
314	1971	FORD	BRON	302	8	2	3	3500	020440	0.60	7.20	2.78	9.98
315	1971	OLDS	CUTL	350	8	4	A	3500	026169	1.00	12.00	3.81	15.81
316	1970	MERC	MONT	302	8	2	3	3500	027532	0.70	8.40	2.78	11.18
317	1971	FORD	MAVE	200	6	1	A	2750	023567	0.30	3.60	0.00	3.60
318	1971	FORD	GALA	400	8	2	A	4000	040209	0.30	3.60	2.78	6.38
319	1971	FORD	TORI	351	8	2	A	3500	013444	0.40	4.80	2.78	7.58
320	1973	FORD	MUST	351	8	2	A	3500	003445	0.60	7.20	2.78	9.98
321	1970	CHEV	NOVA	250	6	1	A	3500	012130	0.30	3.60	0.00	3.60
322	1970	CHEV	NOVA	307	8	2	A	3500	032511	0.80	9.60	4.28	13.88
323	1970	PONT	TEMP	350	8	2	A	3500	030849	1.00	12.00	4.28	16.28
324	1973	CHEV	NOVA	250	6	1	3	3500	004682	0.30	3.60	0.00	3.60
325	1973	FORD	GALA	351	8	2	A	4500	016385	0.60	7.20	2.78	9.98

ALTITUDE RETROFIT EVALUATION

EXHAUST EMISSIONS BEFORE INSTALLATION

1975 FEDERAL TEST PROCEDURE

	# OF	HC		CO		NOX		MPG		DEMERITS	
	VEH.	MEAN	S.D.	MEAN	S.D.	MEAN	S.D.	MEAN	S.D.	MEAN	S.D.
•VEHICLE MAKE											
AMER. MOTORS	4	5.78	2.3	67.3	27.3	2.97	1.1	13.1	0.5	8.2	8.3
BUICK	6	4.86	1.1	100.8	37.2	3.01	1.9	11.4	1.3	8.0	6.7
CADILLAC	2	3.44	0.1	109.5	22.3	1.85	0.3	9.8	1.2	15.5	9.2
CHEVROLET	26	5.11	1.3	72.7	30.7	2.63	1.1	13.6	1.7	12.0	15.0
CHRYSLER	1	4.29	0.0	72.9	0.0	2.43	0.0	11.5	0.0	30.0	0.0
DODGE	6	7.02	4.7	101.7	60.0	2.37	1.0	13.7	1.6	5.3	4.3
FORD	27	5.19	1.4	78.3	31.5	2.57	1.3	14.0	2.3	7.9	9.9
MERCURY	6	5.13	1.0	61.5	24.7	3.67	2.2	14.0	1.4	5.8	5.6
OLDSMOBILE	6	4.67	1.4	75.0	38.0	2.67	1.0	12.7	1.1	10.5	16.0
PLYMOUTH	8	5.81	2.8	102.5	18.3	2.14	0.7	13.6	1.8	6.9	5.1
PONTIAC	8	4.94	0.9	90.3	54.2	3.32	1.5	12.1	1.0	11.4	13.4
•MODEL YEAR											
1968	16	6.00	2.8	98.5	44.8	2.45	1.4	13.4	2.1	12.3	11.8
1969	17	6.00	2.3	88.4	41.5	3.24	1.4	13.5	1.3	7.4	8.5
1970	15	5.22	1.0	87.5	35.1	2.66	0.8	13.4	2.1	11.1	13.0
1971	17	5.03	0.9	70.4	26.9	3.37	1.3	13.4	1.9	12.4	16.9
1972	17	5.06	1.8	70.6	34.4	2.78	1.2	13.0	2.0	8.3	8.5
1973	18	4.20	0.8	75.0	24.2	1.71	0.7	13.3	2.1	5.6	6.2
•DISPLACEMENT											
LESS THAN 151	0										
151 - 250	11	4.45	1.0	72.3	30.0	2.17	1.1	16.7	1.6	12.7	14.5
251 - 350	53	5.49	2.2	83.3	33.6	2.45	1.1	13.5	1.3	9.3	12.5
MORE THAN 350	36	5.10	1.4	81.3	40.5	3.22	1.5	12.1	1.3	8.6	8.1
•INERTIA WEIGHT											
1800 - 2799	3	4.49	1.2	64.7	26.4	2.56	1.7	17.9	2.2	23.0	23.3
2800 - 3799	51	5.44	2.1	80.0	35.8	2.38	1.1	14.1	1.6	7.5	8.3
3800 - 4799	44	5.13	1.6	82.8	36.7	3.11	1.4	12.2	1.0	10.5	12.9
4800 - 5799	2	3.44	0.1	109.5	22.3	1.85	0.3	9.8	1.2	15.5	9.2
ALL VEHICLES	100	5.23	1.8	81.4	35.7	2.70	1.3	13.3	1.9	9.4	11.3

ALTITUDE RETROFIT EVALUATION

EXHAUST EMISSIONS AFTER INSTALLATION

1975 FEDERAL TEST PROCEDURE

	# OF	HC		CO		NOX		MPG		DEMERITS	
	VEH.	MEAN	S.D.	MEAN	S.D.	MEAN	S.D.	MEAN	S.D.	MEAN	S.D.
*VEHICLE MAKE											
AMER. MOTORS	4	6.33	2.7	75.5	30.0	3.49	1.6	13.4	1.6	19.5	13.4
BUICK	6	5.27	0.9	92.1	30.5	3.59	1.7	11.7	1.2	10.7	6.9
CADILLAC	2	5.14	0.6	84.0	39.7	4.41	1.8	10.4	1.2	4.0	0.0
CHEVROLET	26	5.44	2.1	70.4	46.9	3.39	1.5	14.3	3.1	10.0	13.2
CHRYSLER	1	7.57	0.0	68.5	0.0	3.41	0.0	12.3	0.0	58.0	0.0
DODGE	6	5.04	1.5	40.8	19.7	4.68	1.6	14.9	1.7	14.2	18.0
FORD	27	5.17	1.2	72.0	25.9	3.08	1.3	14.4	2.3	7.6	6.2
MERCURY	6	5.00	0.7	53.2	15.2	3.81	2.0	14.4	0.8	7.5	6.1
OLDSMOBILE	6	5.06	1.0	79.5	32.9	3.30	1.7	12.8	0.7	34.0	59.2
PLYMOUTH	8	3.86	0.5	46.9	17.2	3.83	1.2	14.9	2.6	15.4	17.6
PONTIAC	8	4.83	1.3	73.7	46.3	4.10	1.3	12.5	1.1	9.6	8.9
*MODEL YEAR											
1968	16	6.05	2.0	83.8	57.0	3.79	1.6	14.0	2.5	10.4	11.0
1969	17	5.80	1.1	69.8	25.9	4.59	1.6	14.1	1.5	13.5	16.5
1970	15	5.01	1.0	71.1	31.7	3.40	0.9	13.8	1.7	22.9	38.5
1971	17	5.03	1.3	58.9	21.1	4.10	1.0	13.9	2.4	10.9	12.8
1972	17	4.81	1.7	64.0	28.2	3.24	1.2	13.3	2.2	10.5	10.7
1973	18	4.32	1.4	66.0	36.7	2.16	1.1	14.3	3.6	5.7	5.2
*DISPLACEMENT											
LESS THAN 151	0										
151 - 250	11	4.84	1.4	67.6	30.8	2.62	0.9	17.1	1.7	10.3	7.3
251 - 350	53	5.09	1.4	64.2	29.0	3.42	1.5	14.3	2.2	13.6	22.7
MORE THAN 350	36	5.36	1.8	75.7	43.5	3.98	1.5	12.3	1.4	10.4	14.1
*INERTIA WEIGHT											
1800 - 2799	3	4.64	1.2	70.2	17.4	2.58	1.4	17.5	1.0	10.7	5.7
2800 - 3799	51	5.12	1.5	62.6	30.2	3.15	1.4	14.7	1.8	8.3	8.3
3800 - 4799	44	5.24	1.6	75.0	40.4	4.00	1.5	12.8	2.4	16.9	26.0
4800 - 5799	2	5.14	0.6	84.0	39.7	4.41	1.8	10.4	1.2	4.0	0.0
ALL VEHICLES	100	5.16	1.5	68.7	35.1	3.53	1.5	13.9	2.4	12.1	18.7

ALTITUDE RETROFIT EVALUATION

EXHAUST EMISSION REDUCTIONS AFTER INSTALLATION

1975 FEDERAL TEST PROCEDURE

	# OF	HC		CO		NOX		MPG		DEMERITS	
	VEH.	MEAN	S.D.	MEAN	S.D.	MEAN	S.D.	MEAN	S.D.	MEAN	S.D.
*VEHICLE MAKE											
AMER. MOTORS	4	-0.548	0.9	-8.21	41.3	-0.516	1.0	-0.22	1.5	-11.25	15.5
BUICK	6	-0.407	0.7	8.69	38.3	-0.577	1.2	-0.26	0.9	-2.67	8.3
CADILLAC	2	-1.697	0.8	25.52	62.0	-2.565	2.2	-0.60	0.1	11.50	9.2
CHEVROLET	26	-0.331	1.7	2.25	26.4	-0.759	0.7	-0.67	2.8	1.96	16.6
CHRYSLER	1	-3.284	0.0	4.42	0.0	-0.973	0.0	-0.88	0.0	-28.00	0.0
DODGE	6	1.982	3.7	60.88	55.5	-2.317	2.4	-1.17	0.8	-8.83	15.4
FORD	27	0.025	1.4	6.24	23.2	-0.519	0.7	-0.44	1.0	0.30	11.0
MERCURY	6	0.126	0.8	8.32	15.8	-0.138	0.3	-0.43	0.9	-1.67	6.9
OLDSMOBILE	6	-0.396	0.6	-4.51	12.8	-0.633	1.5	-0.07	0.6	-23.50	44.3
PLYMOUTH	8	1.952	2.6	55.61	9.7	-1.693	0.9	-1.30	1.0	-8.50	16.9
PONTIAC	8	0.113	0.8	16.56	20.0	-0.787	1.5	-0.35	0.4	1.75	13.9
*MODEL YEAR											
1968	16	-0.059	3.1	14.69	46.2	-1.342	1.5	-0.60	1.2	1.88	9.0
1969	17	0.198	2.5	18.56	42.4	-1.356	1.7	-0.63	0.7	-6.06	13.0
1970	15	0.207	0.7	16.41	23.2	-0.737	0.7	-0.46	0.8	-11.80	32.1
1971	17	-0.002	0.9	11.52	23.3	-0.727	0.8	-0.48	1.1	1.47	20.5
1972	17	0.249	1.7	6.58	30.7	-0.451	0.8	-0.30	0.8	-2.24	14.6
1973	18	-0.120	1.1	9.05	26.1	-0.451	0.7	-0.93	3.4	-0.11	5.3
*DISPLACEMENT											
LESS THAN 151	0										
151 - 250	11	-0.385	0.9	4.69	23.9	-0.449	0.8	-0.42	1.3	2.45	15.3
251 - 350	53	0.398	1.9	19.08	33.6	-0.969	1.2	-0.86	2.0	-4.28	21.0
MORE THAN 350	36	-0.259	1.8	5.68	32.2	-0.762	1.2	-0.20	0.7	-1.81	12.4
*INERTIA WEIGHT											
1800 - 2799	3	-0.145	0.3	-5.49	10.2	-0.018	0.4	0.37	1.3	12.33	24.0
2800 - 3799	51	0.314	1.8	17.41	33.9	-0.779	1.2	-0.60	1.0	-0.84	11.4
3800 - 4799	44	-0.105	2.0	7.83	30.6	-0.883	1.1	-0.61	2.2	-6.41	22.4
4800 - 5799	2	-1.697	0.8	25.52	62.0	-2.565	2.2	-0.60	0.1	11.50	9.2
ALL VEHICLES	100	0.076	1.8	12.67	32.6	-0.837	1.2	-0.57	1.6	-2.65	17.7

ALTITUDE RETROFIT EVALUATION

PERCENT REDUCTIONS AND REDUCTIONS PER DOLLAR

1975 FEDERAL TEST PROCEDURE

	# OF VEH.	------PERCENT REDUCTIONS------				MILLIGRAMS/MILE/DOLLAR		
		HC	CO	NOX	MPG	HC	CO	NOX
*VEHICLE MAKE								
AMER. MOTORS	4	-9.48	-12.21	-17.37	-1.65	-71.6	-1073.8	-67.5
BUICK	6	-8.38	8.62	-19.18	-2.30	-32.3	689.2	-45.8
CADILLAC	2	-49.31	23.31	-138.76	-6.16	-138.9	2090.2	-210.1
CHEVROLET	26	-6.47	3.10	-28.89	-4.92	-27.6	188.0	-63.4
CHRYSLER	1	-76.63	6.07	-39.98	-7.72	-366.9	493.9	-108.7
DODGE	6	28.24	59.87	-97.90	-8.53	201.1	6175.9	-235.0
FORD	27	0.48	7.97	-20.22	-3.17	2.6	653.7	-54.3
MERCURY	6	2.46	13.53	-3.76	-3.10	12.3	810.0	-13.5
OLDSMOBILE	6	-8.50	-6.02	-23.68	-0.51	-30.2	-343.6	-48.2
PLYMOUTH	8	33.58	54.27	-79.26	-9.60	229.7	6541.9	-199.2
PONTIAC	8	2.28	18.34	-23.71	-2.88	7.8	1148.2	-54.6
*MODEL YEAR								
1968	16	-0.99	14.91	-54.82	-4.46	-5.2	1288.2	-117.7
1969	17	3.29	21.00	-41.89	-4.66	19.3	1809.3	-132.2
1970	15	3.96	18.75	-27.71	-3.47	17.8	1409.3	-63.3
1971	17	-0.03	16.35	-21.59	-3.55	-0.1	1081.0	-68.3
1972	17	4.92	9.32	-16.20	-2.31	22.1	583.7	-40.0
1973	18	-2.86	12.07	-26.33	-7.01	-11.6	870.4	-43.3
*DISPLACEMENT								
LESS THAN 151	0							
151 - 250	11	-8.65	6.49	-20.67	-2.51	-75.2	915.1	-87.7
251 - 350	53	7.26	22.90	-39.59	-6.36	33.6	1610.9	-81.8
MORE THAN 350	36	-5.07	6.98	-23.66	-1.65	-22.9	502.0	-67.3
*INERTIA WEIGHT								
1800 - 2799	3	-3.24	-8.50	-0.71	2.07	-36.3	-1373.7	-4.5
2800 - 3799	51	5.78	21.76	-32.77	-4.21	30.5	1692.0	-75.6
3800 - 4799	44	-2.05	9.45	-28.35	-4.96	-8.7	649.9	-73.3
4800 - 5799	2	-49.31	23.31	-138.76	-6.16	-138.9	2090.2	-210.1
ALL VEHICLES	100	1.44	15.57	-31.06	-4.29	6.9	1161.1	-76.7

MODIFIED TUNING SPECIFICATION EVALUATION VEHICLES

VEH	YEAR	MAKE	MODEL	CID	CYL	CARB	TRAN	I.WT	ODOM.	RUN
039	1968	PONT	VENT	428	8	4	A	4500	069716	01
057	1971	VOLK	SEDA	97	4	1	4	2000	034981	02
059	1965	CHEV	STAW	327	8	4	A	4000	079730	03
073	1971	FORD	TORI	351	8	2	A	3500	022051	05
074	1965	FORD	FAIR	289	8	2	A	3500	073336	04
103	1973	FORD	MAVE	302	8	2	A	3000	009029	06
106	1964	FORD	GALA	289	8	2	3	4500	030087	07
111	1972	FORD	TORI	302	8	2	A	4000	017170	08
112	1970	FORD	MUST	351	8	2	A	3500	051330	09
113	1969	CHEV	STAW	350	8	4	A	4000	075334	10
115	1967	CHEV	IMPA	283	8	2	A	4000	064860	11
123	1964	CHEV	IMP	283	8	2	A	4000	085172	12
147	1970	CHEV	IMPA	350	8	2	A	4000	080466	14
149	1966	FORD	GALA	352	8	4	A	4000	078274	13
175	1972	CHEV	NOVA	350	8	2	A	3500	021117	15
179	1973	CHEV	NOVA	307	8	2	A	3500	017115	20
180	1968	FORD	GALA	302	8	2	A	4000	076747	19
181	1968	CHEV	NOVA	307	8	2	A	3000	042449	18
183	1971	CHEV	STAW	400	8	2	A	4500	021163	17
193	1969	FORD	FAIR	302	8	2	3	3500	054596	16
198	1966	CHEV	IMPA	283	8	2	A	4000	083297	24
210	1973	VOLK	SEDA	97	4	1	4	2000	015868	21
212	1967	FORD	MUST	289	8	2	3	3000	051835	22
214	1966	PONT	CATA	389	8	2	A	4000	046086	23
289	1969	VOLK	SEDA	91	4	1	4	2000	063512	25

MODIFIED TUNING SPECIFICATION EVALUATION

EXHAUST EMISSIONS

1975 FEDERAL TEST PROCEDURE

PARAMETERS AT EXPIREMENTAL SETTING	# OF TESTS	HC MEAN	HC S.D.	CO MEAN	CO S.D.	NOX MEAN	NOX S.D.	MPG MEAN	MPG S.D.	DEMERITS MEAN	DEMERITS S.D.
*SINGLE ITEMS											
A-F RATIO	99	6.42	2.8	86.7	43.5	2.92	1.6	14.5	3.0	23.8	32.0
BASIC TIMING	100	7.32	3.5	92.3	45.0	3.17	1.7	14.6	2.8	25.0	35.0
IDLE RPM	100	6.83	3.2	94.6	45.3	2.83	1.6	14.2	2.8	24.2	32.5
CHOKE SETTING	100	7.04	3.3	92.5	44.6	2.91	1.6	14.4	2.9	25.7	34.3
*COMBINATIONS OF TWO											
A/F-TIMING	50	6.75	3.0	84.5	40.6	3.37	1.8	14.7	3.0	26.0	34.4
A/F-RPM	50	6.44	2.9	86.3	43.6	3.02	1.7	14.3	2.9	25.2	34.7
A/F-CHOKE	51	6.41	2.8	84.7	42.0	3.06	1.7	14.5	3.0	26.8	37.2
TIMING-RPM	50	7.20	3.6	91.9	45.1	3.24	1.8	14.4	2.8	27.4	38.4
TIMING-CHOKE	51	7.62	3.8	89.1	44.3	3.34	1.8	14.7	2.7	27.6	38.8
RPM-CHOKE	50	7.03	3.3	92.9	43.0	3.03	1.8	14.3	2.8	27.3	34.1
AF-TIM. ONLY	23	6.82	3.0	88.2	43.3	3.10	1.7	15.0	3.1	22.2	25.7
AF-RPM ONLY	25	6.07	2.7	89.6	48.0	2.47	1.2	14.1	2.9	19.0	25.6
AF-CHOKE ONLY	24	6.11	2.5	88.6	45.9	2.45	1.1	14.4	3.3	24.1	33.5
TIM.-RPM ONLY	24	7.25	3.7	103.5	48.5	2.85	1.5	14.1	2.7	24.2	36.0
TIM.-CHOKE ONLY	23	8.36	4.0	100.7	48.4	2.96	1.6	14.7	2.7	26.7	37.9
RPM-CHOKE ONLY	24	6.89	3.0	105.4	43.6	2.40	1.2	13.9	2.8	23.9	25.1
*COMBINATIONS OF FOUR											
ALL PARAMETERS	25	6.81	3.1	83.1	39.5	3.56	2.0	14.5	2.9	31.5	41.5
MANUF. SPECS.	25	7.00	2.9	107.9	44.2	2.08	0.9	14.5	3.3	15.2	16.3

MODIFIED TUNING SPECIFICATION EVALUATION

EXHAUST EMISSION REDUCTIONS FROM MANUFACTURERS SPECIFICATIONS

1975 FEDERAL TEST PROCEDURE

PARAMETERS AT EXPIREMENTAL SETTING	# OF TESTS	HC MEAN	HC S.D.	CO MEAN	CO S.D.	NOX MEAN	NOX S.D.	MPG MEAN	MPG S.D.	DEMERITS MEAN	DEMERITS S.D.
*SINGLE ITEMS											
A-F RATIO	99	0.611	2.2	21.66	22.2	-0.854	1.0	-0.03	1.0	-8.67	25.7
BASIC TIMING	100	-0.318	2.5	15.54	23.5	-1.093	1.1	-0.14	1.2	-9.89	30.2
IDLE RPM	100	0.171	2.2	13.28	23.3	-0.756	1.0	0.25	1.1	-9.05	25.9
CHOKE SETTING	100	-0.046	2.4	15.34	24.2	-0.835	1.1	0.04	1.1	-10.50	28.2
*COMBINATIONS OF TWO											
A/F-TIMING	50	0.250	2.3	23.41	23.1	-1.296	1.2	-0.27	1.0	-10.88	28.7
A/F-RPM	50	0.556	2.2	21.52	23.5	-0.939	1.1	0.13	1.1	-10.08	26.1
A/F-CHOKE	51	0.580	2.1	24.25	23.2	-0.996	1.1	-0.04	0.9	-12.14	30.5
TIMING-RPM	50	-0.208	2.5	15.92	24.4	-1.164	1.2	0.09	1.1	-12.28	32.9
TIMING-CHOKE	51	-0.648	2.8	18.64	25.8	-1.261	1.2	-0.19	1.1	-12.73	32.2
RPM-CHOKE	50	-0.035	2.5	15.00	26.1	-0.949	1.2	0.19	1.0	-12.14	26.5
AF-TIM. ONLY	23	0.335	2.5	19.57	20.3	-1.038	1.0	-0.40	0.9	-6.26	23.2
AF-RPM ONLY	25	0.927	2.1	18.31	21.9	-0.395	0.6	0.34	1.2	-3.80	14.3
AF-CHOKE ONLY	24	1.032	1.8	21.50	20.8	-0.411	0.5	0.09	0.9	-9.12	28.6
TIM.-RPM ONLY	24	-0.197	1.7	4.59	16.6	-0.769	1.0	0.33	1.2	-8.46	33.4
TIM.-CHOKE ONLY	23	-1.199	2.5	7.05	20.9	-0.899	1.1	-0.15	1.2	-10.74	33.1
RPM-CHOKE ONLY	24	0.163	1.8	2.68	20.2	-0.321	0.6	0.56	1.0	-8.17	17.3
*COMBINATIONS OF FOUR											
ALL PARAMETERS	25	0.185	2.3	24.73	25.1	-1.483	1.3	-0.07	1.0	-16.36	33.3
MANUF. SPECS.	25	0.000	0.0	0.00	0.0	0.000	0.0	0.00	0.0	0.00	0.0

MODIFIED TUNING SPECIFICATION EVALUATION

PERCENT REDUCTIONS FROM MANUFACTURERS SPECIFICATIONS

1975 FEDERAL TEST PROCEDURE

PARAMETERS AT EXPERIMENTAL SETTING	# OF TESTS	PERCENT REDUCTIONS			
		HC	CO	NOX	MPG
•SINGLE ITEMS					
A-F RATIO	99	9.51	24.97	-29.23	-0.21
BASIC TIMING	100	-4.35	16.93	-34.47	-0.94
IDLE RPM	100	2.50	14.04	-26.67	1.78
CHOKE SETTING	100	-0.65	16.58	-28.67	0.28
•COMBINATIONS OF TWO					
A/F-TIMING	50	3.71	27.72	-38.42	-1.85
A/F-RPM	50	8.63	24.92	-31.12	0.93
A/F-CHOKE	51	9.04	28.62	-32.56	-0.30
TIMING-RPM	50	-2.89	17.31	-35.91	0.59
TIMING-CHOKE	51	-8.50	20.90	-37.77	-1.30
RPM-CHOKE	50	-0.50	16.16	-31.36	1.37
AF-TIM. ONLY	23	4.91	22.19	-33.44	-2.67
AF-RPM ONLY	25	15.28	20.44	-15.96	2.39
AF-CHOKE ONLY	24	16.90	24.27	-16.81	0.65
TIM.-RPM ONLY	24	-2.72	4.43	-27.00	2.33
TIM.-CHOKE ONLY	23	-14.35	7.00	-30.31	-0.99
RPM-CHOKE ONLY	24	2.37	2.54	-13.37	4.01
•COMBINATIONS OF FOUR					
ALL PARAMETERS	25	2.71	29.75	-41.64	-0.48
MANUF. SPECS.	25	0.00	0.00	0.00	0.00

MANDATORY MAINTENANCE EVALUATION VEHICLES

										LABOR	-------COSTS-------		
VEH	YEAR	MAKE	MODEL	CID	CYL	CARB	TRAN	I.WT	ODOM.	HOURS	LABOR	PARTS	TOTAL
015	1967	FORD	STAW	289	8	2	3	3500	060240	1.80	21.60	22.75	44.35
017	1966	CHEV	BISC	283	8	2	A	4000	051045	2.80	33.60	23.51	57.11
021	1967	PLYM	BELV	273	8	2	A	3500	070009	1.90	22.80	21.31	44.11
025	1966	DODG	VAN	273	8	2	3	3500	054740	1.90	22.80	21.31	44.11
028	1964	OLDS	STAW	330	8	2	A	4000	039020	2.80	33.60	23.51	57.11
029	1965	PONT	TEMP	326	8	2	A	3500	059585	2.80	33.60	23.51	57.11
035	1965	DODG	POLA	383	8	2	A	4000	064463	1.90	22.80	21.31	44.11
037	1964	FORD	FAIR	289	8	2	3	3500	052629	1.80	21.60	22.75	44.35
039	1968	PONT	VENT	428	8	4	A	4500	069716	2.80	33.60	25.17	58.77
040	1968	FORD	CUST	302	8	2	A	4000	019445	1.80	21.60	22.75	44.35
041	1970	CHEV	NOVA	230	6	2	A	3000	030980	1.90	22.80	19.41	42.21
042	1969	PLYM	BELV	318	8	2	A	3500	039269	1.90	22.80	21.31	44.11
043	1971	FORD	MAVE	170	6	2	3	2750	020583	1.60	19.20	18.55	37.75
045	1972	DODG	DART	225	6	1	A	3000	005414	1.60	19.20	17.41	36.61
057	1971	VOLK	SEDA	97	4	1	4	2000	034981	2.00	24.00	10.55	34.55
059	1965	CHEV	STAW	327	8	4	A	4000	079730	2.80	33.60	23.51	57.11
070	1972	PONT	CATA	400	8	2	A	4500	016700	2.80	33.60	23.51	57.11
073	1971	FORD	TORI	351	8	2	A	3500	022051	1.80	21.60	22.75	44.35
074	1965	FORD	FAIR	289	8	2	A	3500	073336	1.80	21.60	22.75	44.35
077	1972	CHEV	IMPA	400	8	4	A	4500	027848	2.80	33.60	25.17	58.77
082	1971	PLYM	STAW	383	8	2	A	4000	050843	1.90	22.80	21.31	44.11
091	1973	PONT	LEMA	400	8	2	A	4000	006704	2.80	33.60	23.51	57.11
098	1972	FORD	MAVE	302	8	2	A	3000	026575	1.80	21.60	22.75	44.35
099	1971	CHEV	BLAZ	350	8	4	4	4000	019987	2.80	33.60	25.17	58.77
100	1969	FORD	MUST	302	8	2	A	3000	047190	1.80	21.60	22.75	44.35
101	1969	CHEV	STAW	327	8	2	A	4500	068576	2.80	33.60	23.51	57.11
103	1973	FORD	MAVE	302	8	2	A	3000	009029	1.80	21.60	22.75	44.35
104	1968	PLYM	BELV	273	8	2	A	3500	058630	1.90	22.80	21.31	44.11
106	1964	FORD	GALA	289	8	2	3	4500	030087	1.80	21.60	22.75	44.35
111	1972	FORD	TORI	302	8	2	A	4000	017170	1.80	21.60	22.75	44.35
112	1970	FORD	MUST	351	8	2	A	3500	051330	1.80	21.60	22.75	44.35
113	1969	CHEV	STAW	350	8	4	A	4000	075334	2.80	33.60	25.17	58.77
115	1967	CHEV	IMPA	283	8	2	A	4000	064860	2.80	33.60	23.51	57.11
117	1970	OLDS	CUTL	350	8	2	A	4000	053727	2.80	33.60	23.51	57.11
123	1964	CHEV	IMP	283	8	2	A	4000	085172	2.80	33.60	23.51	57.11
125	1971	PONT	CATA	400	8	2	A	4500	029602	2.80	33.60	23.51	57.11
133	1970	FORD	TORI	351	8	2	A	3500	045898	1.80	21.60	22.75	44.35
139	1970	FORD	TORI	250	6	1	3	3500	031895	1.60	19.20	18.55	37.75
140	1966	OLDS	DYNA	425	8	2	A	4500	048553	2.80	33.60	23.51	57.11
142	1972	CHEV	NOVA	350	8	2	A	3500	025592	2.80	33.60	23.51	57.11

MANDATORY MAINTENANCE EVALUATION VEHICLES

VEH	YEAR	MAKE	MODEL	CID	CYL	CARB	TRAN	I.WT	ODOM.	LABOR HOURS	COSTS LABOR	COSTS PARTS	COSTS TOTAL
143	1966	FORD	MUST	289	8	2	A	3000	038659	1.80	21.60	22.75	44.35
144	1972	FORD	GALA	400	8	2	A	4000	012721	1.80	21.60	22.75	44.35
145	1973	FORD	MAVE	302	8	2	A	3000	005516	1.80	21.60	22.75	44.35
146	1969	OLDS	DELT	455	8	2	A	4000	061594	2.80	33.60	25.17	58.77
147	1970	CHEV	IMPA	350	8	2	A	4000	080466	2.80	33.60	23.51	57.11
148	1972	PLYM	SATE	400	8	2	A	3500	014660	1.90	22.80	21.31	44.11
149	1966	FORD	GALA	352	8	4	A	4000	078274	1.80	21.60	22.75	44.35
150	1971	DODG	DART	318	8	2	A	3000	026700	1.90	22.80	21.31	44.11
152	1971	FORD	GALA	351	8	2	A	4000	029562	1.80	21.60	22.75	44.35
153	1965	CHEV	BELA	283	8	2	A	4000	130460	2.80	33.60	23.51	57.11
155	1968	CHEV	BELA	307	8	2	A	4000	066417	2.80	33.60	23.51	57.11
156	1971	VOLK	SEDA	97	4	1	4	2000	024425	2.00	24.00	10.55	34.55
161	1969	MERC	COUG	351	8	2	A	3500	047191	1.80	21.60	22.75	44.35
166	1970	VOLK	SEDA	97	4	1	4	2000	012474	2.00	24.00	10.55	34.55
169	1965	PLYM	FURY	318	8	2	A	4000	113497	1.90	22.80	21.31	44.11
171	1965	FORD	STAW	289	8	2	A	4500	071092	1.80	21.60	22.75	44.35
172	1964	CHEV	IMPA	283	8	2	A	3500	110629	2.80	33.60	23.51	57.11
173	1972	OLDS	CUTL	350	8	2	A	3500	026639	2.80	33.60	23.51	57.11
175	1972	CHEV	NOVA	350	8	2	A	3500	021117	2.80	33.60	23.51	57.11
178	1964	FORD	GALA	390	8	4	A	4000	059024	1.80	21.60	22.75	44.35
179	1973	CHEV	NOVA	307	8	2	A	3500	017115	2.80	33.60	23.51	57.11
180	1968	FORD	GALA	302	8	2	A	4000	076747	1.80	21.60	22.75	44.35
181	1968	CHEV	NOVA	307	8	2	A	3000	042449	2.80	33.60	23.51	57.11
182	1968	CHEV	CAME	327	8	2	A	3500	083926	2.80	33.60	23.51	57.11
183	1971	CHEV	STAW	400	8	2	A	4500	021163	2.80	33.60	23.51	57.11
184	1971	CHEV	IMPA	350	8	2	A	4000	035988	2.80	33.60	23.51	57.11
187	1973	FORD	LTD	351	8	2	A	4500	004725	1.80	21.60	22.75	44.35
188	1971	MERC	COUG	351	8	2	A	4000	017215	1.80	21.60	22.75	44.35
193	1969	FORD	FAIR	302	8	2	3	3500	054596	1.80	21.60	22.75	44.35
194	1968	CHEV	IMPA	327	8	4	A	4000	054000	2.80	33.60	25.17	58.77
195	1973	CHEV	CHEV	350	8	2	A	4000	006886	2.80	33.60	23.51	57.11
196	1971	CHEV	CAPR	400	8	2	A	4500	036250	2.80	33.60	23.51	57.11
198	1966	CHEV	IMPA	283	8	2	A	4000	083297	2.80	33.60	23.51	57.11
200	1972	CHEV	NOVA	307	8	2	A	3500	015710	2.80	33.60	23.51	57.11
204	1970	FORD	GALA	390	8	2	A	4000	020723	1.80	21.60	22.75	44.35
205	1969	CHEV	STAW	350	8	4	A	4500	093878	2.80	33.60	25.17	58.77
210	1973	VOLK	SEDA	97	4	1	4	2000	015868	2.00	24.00	10.55	34.55
211	1970	PLYM	FURY	318	8	2	A	4000	063652	1.90	22.80	21.31	44.11
212	1967	FORD	MUST	289	8	2	3	3000	051835	1.80	21.60	22.75	44.35
214	1966	PONT	CATA	389	8	2	A	4000	046086	2.80	33.60	23.51	57.11

MANDATORY MAINTENANCE EVALUATION VEHICLES

										LABOR	--------COSTS--------		
VEH	YEAR	MAKE	MODEL	CID	CYL	CARB	TRAN	I.WT	ODOM.	HOURS	LABOR	PARTS	TOTAL
217	1972	CADI	COUP	472	8	4	A	5000	017251	2.80	33.60	25.17	58.77
218	1973	CHEV	NOVA	307	8	2	A	3500	016372	2.80	33.60	23.51	57.11
220	1968	BUIC	LESA	350	8	4	A	4500	074568	2.80	33.60	25.17	58.77
224	1968	CHEV	MALI	250	6	1	A	3500	043307	1.90	22.80	19.41	42.21
225	1968	CHEV	STAW	396	8	4	A	4500	048577	2.80	33.60	25.17	58.77
226	1973	DODG	DART	318	8	2	A	3000	003813	1.90	22.80	21.31	44.11
227	1973	AMMO	STAW	304	8	2	A	3000	003437	2.00	24.00	9.55	33.55
231	1973	PLYM	DUST	318	8	2	A	3500	007751	1.90	22.80	21.31	44.11
232	1973	FORD	MAVE	200	6	1	3	2500	003468	1.60	19.20	18.55	37.75
233	1972	BUIC	LESA	350	8	4	A	4500	020861	2.80	33.60	25.17	58.77
234	1968	MERC	COUG	302	8	4	A	3500	074758	1.80	21.60	27.35	48.95
237	1968	CADI	FLEE	472	8	4	A	5000	065733	2.80	33.60	25.17	58.77
238	1969	DODG	CORO	318	8	2	A	3500	051016	1.90	22.80	21.31	44.11
242	1970	FORD	MUST	302	8	2	A	3500	016785	1.80	21.60	22.75	44.35
243	1969	PONT	CATA	400	8	2	A	4000	057823	2.80	33.60	23.51	57.11
245	1968	FORD	FAIR	289	8	2	3	3500	077348	1.80	21.60	22.75	44.35
246	1968	OLDS	DELT	455	8	2	A	4500	114750	2.80	33.60	23.51	57.11
247	1968	FORD	GALA	390	8	2	A	4000	046034	1.80	21.60	22.75	44.35
248	1969	PONT	LEMA	350	8	2	A	4000	027997	2.80	33.60	23.51	57.11
249	1971	PLYM	FURY	383	8	4	A	4000	030259	1.90	22.80	21.93	44.73
250	1970	CHEV	CAME	350	8	2	4	3500	047370	2.80	33.60	23.51	57.11
251	1973	CHEV	IMPA	350	8	4	A	4000	006702	2.80	33.60	25.17	58.77
252	1973	OLDS	OMEG	350	8	4	3	3500	009599	2.80	33.60	25.17	58.77
254	1970	FORD	MUST	302	8	2	A	3000	036423	1.80	21.60	22.75	44.35
255	1972	CHEV	NOVA	307	8	2	A	3000	032867	2.80	33.60	23.51	57.11
261	1969	FORD	MUST	200	6	1	3	3000	068680	1.60	19.20	18.55	37.75
262	1973	CHEV	STAW	454	8	4	A	4500	017416	2.80	33.60	25.17	58.77
265	1969	CHEV	CAPR	327	8	4	A	4000	030213	2.80	33.60	25.17	58.77
267	1967	FORD	FALC	200	6	1	3	2750	103550	1.60	19.20	18.55	37.75
271	1967	PONT	FIRE	326	8	4	A	3500	059028	2.80	33.60	23.51	57.11
272	1966	PLYM	FURY	318	8	2	A	4000	092494	1.90	22.80	21.31	44.11
273	1970	CHEV	CAPR	400	8	2	A	4000	047305	2.80	33.60	23.51	57.11
274	1970	BUIC	SKYL	350	8	4	A	4000	034266	2.80	33.60	25.17	58.77
276	1966	PONT	LEMA	326	8	4	A	3500	073426	2.80	33.60	23.51	57.11
280	1967	CHEV	STAW	327	8	4	3	4000	096491	2.80	33.60	25.17	58.77
282	1968	FORD	FALC	170	6	1	3	3000	097889	1.60	19.20	18.55	37.75
283	1968	PONT	CATA	400	8	4	A	4500	075255	2.80	33.60	25.17	58.77
284	1971	AMMO	AMBA	401	8	4	A	4000	031837	2.00	24.00	9.55	33.55
285	1968	PLYM	BARR	318	8	2	A	3500	060568	1.90	22.80	21.31	44.11
286	1968	DODG	CHAR	318	8	2	A	3500	065609	1.90	22.80	21.31	44.11

MANDATORY MAINTENANCE EVALUATION VEHICLES

											COSTS		
VEH	YEAR	MAKE	MODEL	CID	CYL	CARB	TRAN	I.WT	ODOM.	LABOR HOURS	LABOR	PARTS	TOTAL
287	1971	BUIC	LESA	455	8	4	A	4500	017998	2.80	33.60	25.17	58.77
288	1968	PONT	TEMP	350	8	2	A	3500	040178	2.80	33.60	23.51	57.11
289	1969	VOLK	SEDA	91	4	1	4	2000	063512	2.00	24.00	10.55	34.55
291	1969	PLYM	FURY	318	8	2	A	4000	052667	1.90	22.80	21.31	44.11
292	1971	CHEV	NOVA	307	8	2	A	3500	029533	2.80	33.60	23.51	57.11
293	1972	FORD	MUST	351	8	4	A	3500	019843	1.80	21.60	27.35	48.95
294	1969	CHRY	NEWP	383	8	2	A	4500	065163	1.90	22.80	21.31	44.11
295	1970	DODG	POLA	383	8	2	A	4500	053254	1.90	22.80	21.31	44.11
297	1971	PLYM	DUST	198	6	1	3	3000	027784	1.60	19.20	17.41	36.61
298	1972	AMMO	JAVE	360	8	4	4	3500	023737	2.00	24.00	9.55	33.55
299	1972	PLYM	SATE	318	8	2	A	3500	028091	1.90	22.80	21.31	44.11
301	1973	MERC	COME	302	8	2	A	3000	010804	1.80	21.60	22.75	44.35
302	1973	BUIC	CENT	350	8	4	A	4000	006508	2.80	33.60	25.17	58.77
303	1973	PLYM	DUST	318	8	2	A	3500	006473	1.90	22.80	21.31	44.11
304	1972	DODG	CORO	318	8	2	A	3500	022983	1.90	22.80	21.31	44.11
305	1969	AMMO	AMBA	290	8	2	A	4000	054001	2.00	24.00	8.75	32.75
306	1969	BUIC	ELEC	430	8	4	A	4500	034898	2.80	33.60	25.17	58.77
307	1969	CHEV	NOVA	230	6	1	A	3000	029124	1.90	22.80	19.41	42.21
308	1969	FORD	TORI	351	8	2	A	3500	021037	1.80	21.60	22.75	44.35
309	1969	FORD	TORI	351	8	2	A	3500	074369	1.80	21.60	22.75	44.35
310	1972	FORD	MAVE	302	8	2	A	3000	008455	1.80	21.60	22.75	44.35
311	1972	FORD	MAVE	250	6	1	A	2750	022036	1.60	19.20	18.55	37.75
312	1972	MERC	COME	302	8	2	A	3000	008589	1.80	21.60	22.75	44.35
314	1971	FORD	BRON	302	8	2	3	3500	020440	1.80	21.60	22.75	44.35
315	1971	OLDS	CUTL	350	8	4	A	3500	026169	2.80	33.60	25.17	58.77
316	1970	MERC	MONT	302	8	2	3	3500	027532	1.80	21.60	22.75	44.35
317	1971	FORD	MAVE	200	6	1	A	2750	023567	1.60	19.20	18.55	37.75
318	1971	FORD	GALA	400	8	2	A	4000	040209	1.80	21.60	22.75	44.35
319	1971	FORD	TORI	351	8	2	A	3500	013444	1.80	21.60	22.75	44.35
320	1973	FORD	MUST	351	8	2	A	3500	003445	1.80	21.60	22.75	44.35
321	1970	CHEV	NOVA	250	6	1	A	3500	012130	1.90	22.80	19.41	42.21
322	1970	CHEV	NOVA	307	8	2	A	3500	032511	2.80	33.60	23.51	57.11
323	1970	PONT	TEMP	350	8	2	A	3500	030849	2.80	33.60	23.51	57.11
324	1973	CHEV	NOVA	250	6	1	3	3500	004682	1.90	22.80	19.41	42.21
325	1973	FORD	GALA	351	8	2	A	4500	016385	1.80	21.60	22.75	44.35

MANDATORY MAINTENANCE EVALUATION

EXHAUST EMISSIONS BEFORE MAINTENANCE

1975 FEDERAL TEST PROCEDURE

	# OF	HC		CO		NOX		MPG	
	VEH.	MEAN	S.D.	MEAN	S.D.	MEAN	S.D.	MEAN	S.D.
*VEHICLE MAKE									
AMER. MOTORS	4	6.60	2.60	99.2	30.8	2.41	1.26	12.75	0.94
BUICK	6	5.92	2.03	127.4	42.6	2.45	1.01	11.28	1.41
CADILLAC	2	3.80	1.01	111.3	10.3	1.84	0.69	9.92	1.34
CHEVROLET	41	8.85	8.49	110.3	64.3	2.57	1.36	13.09	1.96
CHRYSLER	1	4.63	0.00	73.8	0.0	2.43	0.00	11.90	0.00
DODGE	9	7.68	5.76	106.4	38.2	2.79	1.03	14.25	1.59
FORD	45	7.19	4.44	88.3	32.1	3.02	1.65	14.42	2.62
MERCURY	6	5.31	1.04	62.3	23.7	3.24	1.72	14.69	1.77
OLDSMOBILE	8	6.70	3.63	117.8	49.1	2.33	1.09	11.88	0.97
PLYMOUTH	15	8.57	6.36	129.6	47.9	2.27	1.18	13.37	1.84
PONTIAC	13	7.40	4.34	113.7	53.6	2.84	1.37	12.30	1.04
VOLKSWAGEN	5	5.41	0.93	80.3	13.0	1.89	0.47	21.22	1.23
*MODEL YEAR									
1964	6	12.27	2.66	160.9	33.6	1.61	0.59	12.74	0.92
1965	7	12.95	6.87	183.6	70.7	1.79	1.56	12.27	1.67
1966	9	13.59	11.70	140.9	35.6	2.43	0.90	12.92	1.61
1967	7	11.12	4.07	145.0	52.5	1.75	1.40	14.98	3.42
1968	21	6.98	2.22	113.2	58.8	3.01	1.98	13.56	2.07
1969	21	7.46	7.42	95.7	39.9	3.11	1.11	13.80	2.70
1970	19	7.87	6.06	89.7	39.4	3.17	1.19	14.20	2.58
1971	23	6.68	5.07	85.0	29.6	3.39	1.47	14.00	3.65
1972	21	5.11	1.63	90.0	31.5	2.61	0.97	13.22	2.31
1973	21	4.22	1.03	75.3	21.5	1.80	0.63	13.65	2.45
*DISPLACEMENT									
LESS THAN 151	5	5.41	0.93	80.3	13.0	1.89	0.47	21.22	1.23
151 - 250	15	5.07	1.66	80.4	26.3	2.41	1.10	16.98	2.89
251 - 350	88	8.75	6.85	112.3	55.9	2.53	1.33	13.49	1.64
MORE THAN 350	47	6.24	3.91	97.1	37.0	3.15	1.51	12.03	1.47
*INERTIA WEIGHT									
1800 - 2799	10	4.99	1.16	75.5	21.6	2.26	1.07	20.28	2.71
2800 - 3799	74	6.79	3.41	94.7	41.3	2.52	1.21	14.30	1.65
3800 - 4799	69	8.79	7.71	116.9	55.5	2.94	1.57	12.07	1.18
4800 - 5799	2	3.80	1.01	111.3	10.3	1.84	0.69	9.92	1.34
*POPULATIONS									
1964 - 1967	29	12.57	7.41	156.4	50.2	1.94	1.16	13.22	2.25
1968 - 1973	126	6.37	4.65	91.4	39.4	2.85	1.38	13.73	2.66
ALL VEHICLES	155	7.53	5.78	103.6	48.6	2.68	1.38	13.64	2.59

MANDATORY MAINTENANCE EVALUATION

EXHAUST EMISSIONS AFTER MAINTENANCE

1975 FEDERAL TEST PROCEDURE

	# OF	HC		CO		NOX		MPG	
	VEH.	MEAN	S.D.	MEAN	S.D.	MEAN	S.D.	MEAN	S.D.
*VEHICLE MAKE									
AMER. MOTORS	4	5.78	2.26	67.3	27.3	2.97	1.13	13.13	0.47
BUICK	6	4.86	1.12	100.8	37.2	3.01	1.92	11.44	1.32
CADILLAC	2	3.44	0.14	109.5	22.3	1.85	0.33	9.81	1.22
CHEVROLET	41	6.16	2.71	96.5	52.5	2.27	1.10	13.42	1.60
CHRYSLER	1	4.29	0.00	72.9	0.0	2.43	0.00	11.46	0.00
DODGE	9	7.77	5.16	116.1	59.5	2.25	1.02	14.05	2.03
FORD	45	6.26	2.87	85.3	34.3	2.55	1.22	14.41	2.60
MERCURY	6	5.13	0.99	61.5	24.7	3.67	2.15	14.01	1.42
OLDSMOBILE	8	5.61	2.17	98.9	55.1	2.37	1.04	12.48	1.02
PLYMOUTH	15	6.26	2.43	112.7	29.5	2.12	0.79	13.65	1.93
PONTIAC	13	6.21	1.93	104.7	48.1	2.80	1.44	12.43	0.99
VOLKSWAGEN	5	4.95	1.02	75.1	8.4	1.62	0.28	22.23	1.14
*MODEL YEAR									
1964	6	11.02	2.79	167.8	33.7	1.21	0.75	12.70	1.20
1965	7	9.71	2.32	160.3	33.3	1.60	0.84	12.92	1.05
1966	9	9.32	3.03	135.3	43.8	2.33	1.06	13.43	1.38
1967	7	9.64	3.44	133.9	45.3	1.68	1.25	15.57	3.28
1968	21	6.12	2.66	98.3	41.3	2.47	1.26	13.41	1.91
1969	21	5.95	2.18	86.0	37.8	3.16	1.36	14.20	2.49
1970	19	5.14	1.06	83.1	33.6	2.60	0.82	13.97	2.76
1971	23	4.90	0.90	73.0	27.8	3.07	1.30	14.47	3.75
1972	21	5.01	1.67	76.5	34.0	2.69	1.14	13.20	2.12
1973	21	4.20	0.81	74.9	22.6	1.69	0.70	13.69	2.57
*DISPLACEMENT									
LESS THAN 151	5	4.95	1.02	75.1	8.4	1.62	0.28	22.23	1.14
251 - 250	15	4.32	0.88	68.8	27.7	2.45	1.08	17.58	2.33
251 - 350	88	6.68	3.02	103.0	46.0	2.20	1.10	13.55	1.36
MORE THAN 350	47	5.65	2.22	87.7	40.7	3.05	1.34	12.17	1.30
*INERTIA WEIGHT									
1800 - 2799	10	4.65	0.99	67.9	16.4	2.24	1.19	20.93	2.44
2800 - 3799	74	6.01	2.73	89.0	41.3	2.29	1.10	14.28	1.64
3800 - 4799	69	6.44	2.80	103.0	46.9	2.70	1.34	12.37	1.01
4800 - 5799	2	3.44	0.14	109.5	22.3	1.85	0.33	9.81	1.22
*POPULATIONS									
1964 - 1967	29	9.84	2.85	147.7	40.6	1.77	1.04	13.67	2.15
1968 - 1973	126	5.22	1.78	81.8	33.8	2.62	1.21	13.83	2.67
ALL VEHICLES	155	6.08	2.71	94.1	43.5	2.46	1.22	13.80	2.57

MANDATORY MAINTENANCE EVALUATION

EXHAUST EMISSION REDUCTIONS AFTER MAINTENANCE

1975 FEDERAL TEST PROCEDURE

	# OF	HC		CO		NOX		MPG	
	VEH.	MEAN	S.D.	MEAN	S.D.	MEAN	S.D.	MEAN	S.D.
*VEHICLE MAKE									
AMER. MOTORS	4	0.819	1.16	31.88	38.22	-0.562	1.00	-0.386	0.69
BUICK	6	1.054	1.12	26.63	39.55	-0.560	1.37	-0.156	1.39
CADILLAC	2	0.357	1.15	1.76	11.92	-0.011	0.36	0.111	0.13
CHEVROLET	41	2.694	7.39	13.82	39.44	0.309	0.86	-0.337	1.27
CHRYSLER	1	0.340	0.00	0.91	0.00	0.001	0.00	0.443	0.00
DODGE	9	-0.090	3.61	-9.63	39.02	0.540	0.92	0.203	0.71
FORD	45	0.928	4.05	3.01	24.76	0.470	1.15	0.009	1.03
MERCURY	6	0.186	1.25	0.83	25.44	-0.436	1.30	0.673	1.48
OLDSMOBILE	8	1.087	3.30	18.89	23.43	-0.039	0.55	-0.604	0.77
PLYMOUTH	15	2.309	6.48	16.91	21.85	0.152	0.63	-0.287	1.16
PONTIAC	13	1.195	4.28	8.96	25.10	0.038	0.56	-0.135	1.07
VOLKSWAGEN	5	0.452	1.07	5.25	14.87	0.270	0.29	-1.003	1.45
*MODEL YEAR									
1964	6	1.253	3.98	-6.88	22.60	0.400	0.25	0.046	0.90
1965	7	3.243	5.76	23.36	45.16	0.183	0.96	-0.649	1.12
1966	9	4.276	10.57	5.59	22.84	0.091	0.46	-0.514	1.03
1967	7	1.483	1.89	11.13	23.08	0.070	0.42	-0.594	0.71
1968	21	0.859	3.23	14.88	47.31	0.539	1.22	0.148	1.37
1969	21	1.510	7.50	9.71	40.97	-0.044	1.15	-0.397	1.20
1970	19	2.733	6.06	6.58	26.79	0.571	1.38	0.237	1.32
1971	23	1.780	5.24	12.00	17.79	0.318	0.78	-0.475	0.95
1972	21	0.104	1.28	13.50	29.72	-0.078	0.94	0.020	1.13
1973	21	0.021	0.62	0.38	13.75	0.111	0.35	-0.047	0.89
*DISPLACEMENT									
LESS THAN 151	5	0.452	1.07	5.25	14.87	0.270	0.29	-1.003	1.45
151 - 250	15	0.757	1.56	11.58	27.90	-0.045	0.58	-0.604	1.14
251 - 350	88	2.077	6.05	9.30	35.17	0.331	0.92	-0.054	1.19
MORE THAN 350	47	0.594	4.02	9.38	24.84	0.095	1.14	-0.137	0.92
*INERTIA WEIGHT									
1800 - 2799	10	0.341	0.84	7.69	20.96	0.016	0.58	-0.645	1.21
2800 - 3799	74	0.782	2.41	5.66	26.02	0.230	0.98	0.021	1.18
3800 - 4799	69	2.352	7.19	13.92	36.74	0.248	1.00	-0.298	1.05
4800 - 5799	2	0.357	1.15	1.76	11.92	-0.011	0.36	0.111	0.13
*POPULATIONS									
1964 - 1967	29	2.727	6.66	8.64	30.03	0.172	0.57	-0.450	0.94
1968 - 1973	126	1.153	4.69	9.59	31.32	0.232	1.03	-0.097	1.16
ALL VEHICLES	155	1.447	5.13	9.41	30.99	0.221	0.96	-0.163	1.13

MANDATORY MAINTENANCE EVALUATION

PERCENT REDUCTIONS AND REDUCTIONS PER DOLLAR

1975 FEDERAL TEST PROCEDURE

	# OF	------PERCENT	REDUCTIONS------			MILLIGRAMS/MILE/DOLLAR		
	VEH.	HC	CO	NOX	MPG	HC	CO	NOX
*VEHICLE MAKE								
AMER. MOTORS	4	12.42	32.14	-23.34	-3.03	24.6	955.9	-16.9
BUICK	6	17.81	20.90	-22.83	-1.38	17.9	453.2	-9.5
CADILLAC	2	9.39	1.58	-0.58	1.12	6.1	29.9	-0.2
CHEVROLET	41	30.43	12.53	12.00	-2.57	48.4	248.1	5.5
CHRYSLER	1	7.35	1.23	0.05	3.73	7.7	20.5	0.0
DODGE	9	-1.17	-9.05	19.39	1.42	-2.1	-222.6	12.5
FORD	45	12.92	3.40	15.54	0.06	21.4	69.4	10.9
MERCURY	6	3.50	1.33	-13.47	4.58	4.1	18.4	-9.7
OLDSMOBILE	8	16.22	16.03	-1.65	-5.08	18.8	327.1	-0.7
PLYMOUTH	15	26.94	13.05	6.69	-2.14	52.9	387.3	3.5
PONTIAC	13	16.15	7.88	1.34	-1.10	20.8	156.2	0.7
VOLKSWAGEN	5	8.36	6.53	14.30	-4.73	13.1	151.8	7.8
*MODEL YEAR								
1964	6	10.21	-4.27	24.84	0.36	24.7	-135.6	7.9
1965	7	25.03	12.72	10.27	-5.29	65.2	469.5	3.7
1966	9	31.46	3.97	3.77	-3.98	83.2	108.7	1.8
1967	7	13.33	7.67	3.98	-3.97	30.2	226.8	1.4
1968	21	12.30	13.14	17.92	1.09	16.8	290.2	10.5
1969	21	20.24	10.14	-1.42	-2.88	31.4	201.8	-0.9
1970	19	34.72	7.33	18.01	1.67	56.9	137.0	11.9
1971	23	26.66	14.12	9.38	-3.40	38.1	256.6	6.8
1972	21	2.03	15.00	-2.98	0.15	2.1	275.2	-1.6
1973	21	0.49	0.51	6.16	-0.34	0.4	7.9	2.3
*DISPLACEMENT								
LESS THAN 151	5	8.36	6.53	14.30	-4.73	13.1	151.8	7.8
151 - 250	15	14.92	14.41	-1.86	-3.56	19.4	296.4	-1.1
251 - 350	88	23.73	8.29	13.09	-0.40	40.8	182.9	6.5
MORE THAN 350	47	9.51	9.66	3.02	-1.14	11.9	188.5	1.9
*INERTIA WEIGHT								
1800 - 2799	10	6.84	10.17	0.71	-3.18	9.4	212.6	0.4
2800 - 3799	74	11.52	5.97	9.13	0.14	16.6	120.3	4.9
3800 - 4799	69	26.75	11.90	8.42	-2.47	44.9	265.6	4.7
4800 - 5799	2	9.39	1.58	-0.58	1.12	6.1	29.9	-0.2
*POPULATIONS								
1964 - 1967	29	21.69	5.52	8.88	-3.40	54.2	171.7	3.4
1968 - 1973	126	18.10	10.50	8.14	-0.71	23.7	197.7	4.8
ALL VEHICLES	155	19.22	9.09	8.24	-1.20	29.6	192.7	4.5

IDLE INSPECTION EVALUATION VEHICLES

VEH	YEAR	MAKE	MODEL	CID	CYL	CARB	TRAN	I.WT	ODOM.	FAILURE	---COSTS----	
											INSP.	MTCE.
001	1965	OLDS	DELT	425	8	4	A	4500	040150	PASS	4.00	0.00
002	1967	MERC	COUG	289	8	4	A	3500	070863	CO	2.50	35.00
003	1966	BUIC	LESA	340	8	4	A	4000	022750	BOTH	3.50	16.25
004	1967	BUIC	SPEC	300	8	2	A	3500	048935	CO	4.50	3.60
006	1967	CADI	SEDA	429	8	4	A	5000	104304	CO	1.50	3.00
007	1966	CHEV	IMPA	327	8	4	A	4000	043884	HC	5.50	6.60
008	1964	VOLK	SEDA	73	4	1	4	2000	105861	PASS	5.00	0.00
010	1966	CHRY	300	383	8	4	A	4000	066648	CO	6.00	6.00
011	1966	CHEV	CHE2	194	6	1	3	3000	072251	CO	5.50	5.50
012	1967	CHRY	STAW	383	8	4	A	5000	063004	PASS	2.50	0.50
013	1965	DODG	DART	225	6	1	A	3000	032679	PASS	3.50	0.00
014	1964	CHEV	CHE2	194	6	1	3	3000	049237	PASS	4.00	0.00
015	1967	FORD	STAW	289	8	2	3	3500	060240	CO	5.00	2.00
016	1967	FORD	FALC	289	8	2	A	3000	059003	PASS	5.50	0.00
017	1966	CHEV	BISC	283	8	2	A	4000	051045	PASS	1.50	0.00
019	1965	AMMO	CLAS	232	6	1	3	3000	062545	CO	4.50	3.00
020	1967	OLDS	DELT	425	8	4	A	4500	089113	HC	5.50	9.90
021	1967	PLYM	BELV	273	8	2	A	3500	070009	PASS	6.00	0.00
022	1971	CHEV	VEGA	140	4	2	4	2500	040186	CO	5.50	6.60
023	1973	FORD	STAW	400	8	2	A	5000	003001	HC	3.50	2.00
024	1964	CHRY	NEWP	361	8	2	A	4500	099340	CO	6.00	36.57
025	1966	DODG	VAN	273	8	2	3	3500	054740	PASS	4.00	0.00
026	1965	CADI	DEVI	429	8	4	A	5000	084961	PASS	2.50	0.00
027	1965	MERC	MONR	390	8	2	A	4000	072548	PASS	4.00	0.00
028	1964	OLDS	STAW	330	8	2	A	4000	089020	BOTH	4.50	5.00
029	1965	PONT	TEMP	326	8	2	A	3500	059585	PASS	5.00	0.00
030	1964	CADI	DEVI	429	8	4	A	5000	048156	CO	2.50	7.50
031	1964	CHEV	IMPA	327	8	4	A	3500	060672	CO	2.50	48.07
033	1965	FORD	MUST	200	6	1	A	3000	065042	HC	1.50	4.50
035	1965	DODG	POLA	383	8	2	A	4000	064463	PASS	6.00	0.00
036	1965	BUIC	SKYL	300	8	2	A	3500	075400	BOTH	3.50	15.30
037	1964	FORD	FAIR	289	8	2	3	3500	052629	HC	5.50	5.50
038	1966	FORD	GALA	390	8	4	A	4000	054529	PASS	4.50	0.00
039	1968	PONT	VENT	428	8	4	A	4500	069716	HC	5.50	5.50
040	1968	FORD	CUST	302	8	2	A	4000	019445	HC	1.50	18.84
041	1970	CHEV	NOVA	230	6	2	A	3000	030980	BOTH	5.50	6.60
042	1969	PLYM	BELV	318	8	2	A	3500	039269	BOTH	2.50	7.50
043	1971	FORD	MAVE	170	6	2	3	2750	020583	PASS	5.00	0.00
044	1967	CHEV	CAPR	327	8	4	A	4000	046046	PASS	4.00	0.00
045	1972	DODG	DART	225	6	1	A	3000	005414	HC	6.00	6.00
046	1965	PLYM	VALI	225	6	1	3	3000	085428	PASS	4.00	0.00
048	1967	MERC	STAW	390	8	2	A	4500	064033	PASS	1.50	0.00
049	1967	CHEV	CAMA	250	6	1	4	3000	076864	BOTH	4.50	6.00
051	1969	OLDS	DELT	455	8	2	A	4500	064800	PASS	2.50	0.00
053	1964	DODG	POLA	318	8	2	A	4000	042474	BOTH	3.50	4.50
055	1966	FORD	MUST	200	6	1	A	3000	054749	CO	2.50	7.50
056	1964	CHEV	BELA	230	6	1	A	3500	046660	CO	1.50	0.00
057	1971	VOLK	SEDA	97	4	1	4	2000	034981	CO	5.00	1.00
059	1965	CHEV	STAW	327	8	4	A	4000	079730	BOTH	2.50	10.35
060	1970	CADI	DEVI	472	8	4	A	5000	045946	PASS	4.50	0.00

IDLE INSPECTION EVALUATION VEHICLES

VEH	YEAR	MAKE	MODEL	CID	CYL	CARB	TRAN	I.WT	ODOM.	FAILURE	---COSTS---- INSP.	MTCE.
061	1972	CHEV	VEGA	140	4	2	4	2500	025879	PASS	5.00	0.00
063	1967	PLYM	FURY	318	8	2	A	4000	042005	HC	3.50	7.50
064	1970	AMMO	REBE	232	6	1	A	3500	064875	PASS	4.50	0.00
065	1970	CHRY	NEWP	383	8	2	A	4500	036717	BOTH	6.00	11.20
066	1970	PLYM	DUST	318	8	2	3	3000	037361	BOTH	2.50	7.50
067	1971	CADI	DEVI	472	8	4	A	5000	041770	PASS	2.50	0.00
068	1968	OLDS	CUTL	350	8	2	A	3500	054881	BOTH	5.00	6.00
069	1967	FORD	LTD	390	8	2	A	4000	048253	CO	5.50	11.00
070	1972	PONT	CATA	400	8	2	A	4500	016700	HC	1.50	3.00
071	1972	VOLK	SEDA	97	4	1	4	2250	041347	CO	5.00	1.00
072	1972	CHEV	NOVA	250	6	1	A	3000	012834	BOTH	5.00	4.90
073	1971	FORD	TORI	351	8	2	A	3500	022051	PASS	5.50	0.00
074	1965	FORD	FAIR	289	8	2	A	3500	073336	PASS	3.50	0.00
075	1971	FORD	PINT	98	4	1	4	2250	012609	BOTH	5.00	11.00
076	1967	BUIC	LESA	340	8	4	A	4000	021887	PASS	2.50	0.00
077	1972	CHEV	IMPA	400	8	4	A	4500	027848	PASS	3.50	0.00
078	1972	FORD	STAW	351	8	2	A	4000	020434	PASS	5.50	0.00
079	1971	FORD	STAW	400	8	2	A	4500	035284	BOTH	2.50	18.00
080	1967	CHEV	MALI	283	8	2	3	3500	075280	BOTH	5.50	6.60
082	1971	PLYM	STAW	383	8	2	A	4000	050843	BOTH	6.00	6.00
083	1970	DODG	DART	318	8	2	A	3000	016300	CO	2.50	5.00
084	1970	PONT	GTO	400	8	4	A	4000	042846	HC	4.00	0.00
085	1968	BUIC	RIVI	430	8	4	A	4500	060029	BOTH	5.50	5.50
087	1967	OLDS	STAW	330	8	2	A	4000	064223	PASS	4.50	0.00
088	1967	AMMO	STAW	290	8	2	A	4000	072440	BOTH	2.50	7.50
090	1970	FORD	MAVE	200	6	1	A	2750	022467	PASS	5.00	0.00
091	1973	PONT	LEMA	400	8	2	A	4000	006704	PASS	5.00	0.50
092	1970	FORD	MAVE	200	6	1	A	2750	035000	BOTH	1.50	4.50
093	1972	PLYM	DUST	198	6	1	A	3000	020817	BOTH	6.00	6.00
094	1969	BUIC	LESA	350	8	4	A	4500	034309	BOTH	4.00	0.00
095	1968	AMMO	STAW	290	8	2	A	4000	052932	CO	2.50	4.00
096	1965	PONT	CATA	389	8	4	A	4000	076369	BOTH	3.50	38.05
097	1964	PLYM	VALI	170	6	1	3	3000	026268	PASS	5.50	0.00
098	1972	FORD	MAVE	302	8	2	A	3000	026575	HC	2.50	7.50
099	1971	CHEV	BLAZ	350	8	4	4	4000	019987	BOTH	5.50	3.30
100	1969	FORD	MUST	302	3	2	A	3000	047190	BOTH	5.00	2.00
101	1969	CHEV	STAW	327	8	2	A	4500	068576	BOTH	1.50	70.59
102	1964	MERC	PARK	390	8	4	A	4500	055285	PASS	4.50	0.00
103	1973	FORD	MAVE	302	8	2	A	3000	009029	PASS	5.50	0.00
104	1968	PLYM	BELV	273	8	2	A	3500	058630	BOTH	4.00	0.50
106	1964	FORD	GALA	289	8	2	3	4500	030087	PASS	5.00	0.00
107	1965	CHEV	CORV	164	6	2	4	2750	076078	BOTH	2.50	7.50
108	1964	FORD	FALC	200	6	1	3	3000	087334	PASS	1.50	0.00
109	1966	AMMO	AMER	232	6	1	3	3000	064169	PASS	1.50	0.00
110	1969	CHEV	CHEV	307	8	2	A	3500	045577	CO	2.50	7.50
111	1972	FORD	TORI	302	8	2	A	4000	017170	PASS	3.50	0.00
112	1970	FORD	MUST	351	8	2	A	3500	051330	PASS	4.50	0.00
113	1969	CHEV	STAW	350	8	4	A	4000	075334	CO	6.00	6.00
115	1967	CHEV	IMPA	283	8	2	A	4000	064860	PASS	5.50	0.00
116	1973	CHEV	VEGA	140	4	2	3	2500	009706	BOTH	2.50	7.50

IDLE INSPECTION EVALUATION VEHICLES

											---COSTS----	
VEH	YEAR	MAKE	MODEL	CID	CYL	CARB	TRAN	I.WT	ODOM.	FAILURE	INSP.	MTCE.
117	1970	OLDS	CUTL	350	8	2	A	4000	053727	BOTH	5.00	2.00
118	1967	PONT	CATA	400	8	2	A	4000	071128	PASS	1.50	0.00
119	1971	PONT	LEMA	350	8	2	A	3500	031776	PASS	5.50	0.00
120	1967	DODG	CORO	318	8	2	A	3500	044942	HC	6.00	6.00
121	1967	VOLK	SEDA	91	4	1	4	2000	048582	BOTH	5.00	2.00
122	1967	PONT	FIRE	326	8	2	3	3500	042146	BOTH	2.50	25.49
123	1964	CHEV	IMP	283	8	2	A	4000	085172	PASS	3.50	0.00
124	1973	VOLK	BUS	102	4	2	4	3000	003006	HC	2.50	5.00
125	1971	PONT	CATA	400	8	2	A	4500	029602	PASS	4.00	0.00
126	1966	CHEV	IMPA	327	8	4	A	4000	033735	BOTH	5.50	6.60
127	1966	DODG	CORO	318	8	2	A	3500	048219	CO	6.00	6.00
128	1966	MERC	MONT	390	8	2	A	4000	108053	BOTH	4.50	13.50
129	1965	CHEV	BISC	283	8	2	A	3500	073598	BOTH	3.50	7.00
130	1965	FORD	MUST	200	6	1	3	2750	092515	PASS	2.50	0.00
132	1965	VOLK	SEDA	73	4	1	4	2000	089782	HC	5.50	11.00
133	1970	FORD	TORI	351	8	2	A	3500	045898	BOTH	2.50	43.50
134	1969	DODG	CORO	225	6	1	A	3500	038665	CO	6.00	6.00
135	1969	VOLK	SEDA	91	4	1	4	2000	068227	HC	5.00	4.50
136	1965	OLDS	CUTL	330	8	2	A	3500	045665	PASS	4.00	0.00
137	1964	CHEV	STAW	327	8	4	A	4500	071086	PASS	4.50	0.00
139	1970	FORD	TORI	250	6	1	3	3500	031895	HC	2.50	7.47
140	1966	OLDS	DYNA	425	8	2	A	4500	048553	BOTH	5.50	6.60
141	1972	TOYO	STAW	120	4	2	A	2750	009840	PASS	5.50	0.00
142	1972	CHEV	NOVA	350	8	2	A	3500	025592	PASS	4.00	0.00
143	1966	FORD	MUST	289	8	2	A	3000	038659	PASS	5.00	0.00
144	1972	FORD	GALA	400	8	2	A	4000	012721	BOTH	3.50	4.50
145	1973	FORD	MAVE	302	8	2	A	3000	005516	PASS	1.50	0.00
146	1969	OLDS	DELT	455	8	2	A	4000	061594	CO	4.50	1.50
147	1970	CHEV	IMPA	350	8	2	A	4000	080466	HC	6.00	12.00
148	1972	PLYM	SATE	400	8	2	A	3500	014660	CO	6.00	6.00
149	1966	FORD	GALA	352	8	4	A	4000	078274	CO	5.50	11.00
150	1971	DODG	DART	318	8	2	A	3000	026700	CO	2.50	3.00
151	1971	VOLV	145S	121	4	2	4	3000	045943	PASS	5.00	0.00
152	1971	FORD	GALA	351	8	2	A	4000	029562	HC	4.50	30.01
153	1965	CHEV	BELA	283	8	2	A	4000	130460	PASS	3.50	0.00
154	1968	VOLK	SEDA	91	4	1	A	2000	050486	BOTH	2.50	11.00
155	1968	CHEV	BELA	307	8	2	A	4000	066417	BOTH	1.50	3.00
156	1971	VOLK	SEDA	97	4	1	4	2000	024425	PASS	5.00	0.00
157	1973	VOLK	SEDA	97	4	1	4	2000	007972	PASS	5.50	0.00
158	1970	OLDS	STAW	455	8	4	A	4500	033747	PASS	4.00	0.00
159	1968	CHEV	BELA	250	6	1	A	4000	009065	PASS	5.50	0.00
160	1969	CADI	FLEE	472	8	4	A	5000	036519	PASS	4.50	0.00
161	1969	MERC	COUG	351	8	2	A	3500	047191	PASS	2.50	0.00
162	1964	CHEV	STAW	283	8	4	A	4000	074643	BOTH	3.50	4.50
163	1972	DATS	STAW	97	4	1	4	2500	024888	HC	5.50	12.50
165	1964	PONT	CATA	389	8	2	A	4000	054195	BOTH	2.50	51.45
166	1970	VOLK	SEDA	97	4	1	4	2000	012474	BOTH	5.00	1.00
168	1966	VOLK	SEDA	78	4	1	4	2000	048575	CO	5.50	11.00
169	1965	PLYM	FURY	318	8	2	A	4000	113497	BOTH	6.00	6.00
170	1966	FORD	MUST	289	8	2	A	3000	081058	BOTH	2.50	7.50

IDLE INSPECTION EVALUATION VEHICLES

VEH	YEAR	MAKE	MODEL	CID	CYL	CARB	TRAN	I.WT	ODOM.	FAILURE	---COSTS---- INSP.	MTCE.
171	1965	FORD	STAW	289	8	2	A	4500	071092	CO	3.50	2.50
172	1964	CHEV	IMPA	283	8	2	A	3500	110629	BOTH	5.50	9.90
173	1972	OLDS	CUTL	350	8	2	A	3500	026639	PASS	1.50	0.00
174	1969	FORD	FAIR	302	8	2	A	3500	055127	BOTH	4.50	4.50
175	1972	CHEV	NOVA	350	8	2	A	3500	021117	PASS	2.50	0.00
176	1973	CADI	DEVI	472	8	4	A	5000	007405	PASS	3.50	0.00
177	1972	CHRY	NEWP	400	8	2	A	4500	029493	BOTH	6.00	39.95
178	1964	FORD	GALA	390	8	4	A	4000	059024	PASS	1.50	0.00
179	1973	CHEV	NOVA	307	8	2	A	3500	017115	PASS	2.50	0.00
180	1968	FORD	GALA	302	8	2	A	4000	076747	BOTH	4.50	32.07
181	1968	CHEV	NOVA	307	8	2	A	3000	042449	BOTH	3.50	7.00
182	1968	CHEV	CAME	327	8	2	A	3500	083926	BOTH	4.00	0.00
183	1971	CHEV	STAW	400	8	2	A	4500	021163	PASS	2.50	0.00
184	1971	CHEV	IMPA	350	8	2	A	4000	035988	BOTH	5.50	6.60
185	1971	TOYO	CORO	71	4	2	4	2000	029881	BOTH	5.50	12.50
186	1970	VOLK	SEDA	97	4	1	4	2000	048300	BOTH	5.00	4.00
187	1973	FORD	LTD	351	8	2	A	4500	004725	PASS	1.50	0.00
188	1971	MERC	COUG	351	8	2	A	4000	017215	PASS	4.00	0.00
189	1971	DODG	DART	225	6	1	A	3000	011166	BOTH	6.00	6.00
190	1973	PLYM	DUST	225	6	1	A	3000	008056	PASS	4.00	0.00
191	1967	CHEV	CHE2	194	6	1	3	3000	022266	BOTH	4.50	2.50
192	1966	CHEV	CHEV	230	6	1	A	3500	046973	CO	2.50	5.00
193	1969	FORD	FAIR	302	8	2	3	3500	054596	BOTH	2.50	15.00
194	1968	CHEV	IMPA	327	8	4	A	4000	054000	BOTH	5.50	45.87
195	1973	CHEV	CHEV	350	8	2	A	4000	006886	BOTH	2.50	5.00
196	1971	CHEV	CAPR	400	8	2	A	4500	036250	PASS	3.50	0.00
197	1972	FORD	PINT	122	4	2	A	2250	011175	PASS	1.50	0.00
198	1966	CHEV	IMPA	283	8	2	A	4000	083297	BOTH	4.00	13.85
199	1967	VOLK	SEDA	91	4	1	4	2000	068155	BOTH	5.00	1.00
200	1972	CHEV	NOVA	307	8	2	A	3500	015710	BOTH	5.50	9.90
201	1973	FORD	PINT	122	4	1	A	2500	010729	BOTH	2.50	26.90
202	1973	DATS	1200	71	4	1	4	2000	000519	PASS	5.50	0.00
203	1973	CHRY	NEWP	400	8	2	A	4500	059407	BOTH	6.00	27.45
204	1970	FORD	GALA	390	8	2	A	4000	020723	PASS	4.50	0.00
205	1969	CHEV	STAW	350	8	4	A	4500	093878	BOTH	4.00	6.87
206	1965	CADI	FLEE	429	8	4	A	5500	053146	PASS	3.50	0.00
207	1972	VOLK	SQBK	97	4	FI	4	2500	011511	PASS	5.00	0.00
208	1971	DATS	510	97	4	1	4	2000	027615	BOTH	5.50	5.50
209	1966	BUIC	ELEC	401	8	4	A	4500	056428	BOTH	2.50	7.50
210	1973	VOLK	SEDA	97	4	1	4	2000	015868	CO	5.50	5.50
211	1970	PLYM	FURY	318	8	2	A	4000	063652	HC	6.00	45.08
212	1967	FORD	MUST	289	8	2	3	3000	051835	CO	1.50	3.00
213	1966	CHEV	STAW	283	8	2	3	4000	061637	PASS	5.50	0.00
214	1966	PONT	CATA	389	8	2	A	4000	046086	PASS	2.50	0.00
217	1972	CADI	COUP	472	8	4	A	5000	017251	PASS	4.50	0.00
218	1973	CHEV	NOVA	307	8	2	A	3500	016372	PASS	4.00	0.00
219	1968	CHRY	STAW	383	8	4	A	4500	071302	CO	6.00	6.00
220	1968	BUIC	LESA	350	8	4	A	4500	074568	BOTH	5.50	6.60
221	1964	PONT	GRAN	389	8	4	A	4000	074401	BOTH	2.50	15.00
222	1964	AMMO	AMER	196	6	1	3	3000	068526	PASS	1.50	0.00

IDLE INSPECTION EVALUATION VEHICLES

VEH	YEAR	MAKE	MODEL	CID	CYL	CARB	TRAN	I.WT	ODOM.	FAILURE	---COSTS----	
											INSP.	MTCE.
223	1964	BUIC	WILD	401	8	4	A	4500	051818	HC	2.50	2.00
224	1968	CHEV	MALI	250	6	1	A	3500	043307	CO	4.50	1.50
225	1968	CHEV	STAW	396	8	4	A	4500	048577	BOTH	3.50	56.65
226	1973	DODG	DART	318	8	2	A	3000	003813	BOTH	2.50	7.50
227	1973	AMMO	STAW	304	8	2	A	3000	003437	PASS	4.00	0.00
228	1971	OPEL	1900	116	4	1	A	2250	011626	PASS	5.50	0.00
229	1972	VOLK	SEDA	97	4	1	4	2000	018774	BOTH	5.00	4.00
230	1966	PLYM	BELE	225	6	1	3	3500	099961	CO	6.00	6.00
231	1973	PLYM	DUST	318	8	2	A	3500	007751	BOTH	6.00	6.00
232	1973	FORD	MAVE	200	6	1	3	2500	003468	PASS	1.50	0.00
233	1972	BUIC	LESA	350	8	4	A	4500	020861	PASS	5.00	0.00
234	1968	MERC	COUG	302	8	4	A	3500	074758	BOTH	2.50	49.11
235	1965	BUIC	WILD	425	8	4	A	4500	078046	BOTH	4.50	48.92
236	1965	CHEV	IMPA	327	8	4	A	4000	061259	BOTH	2.50	7.50
237	1968	CADI	FLEE	472	8	4	A	5000	065733	PASS	4.00	0.00
238	1969	DODG	CORO	318	8	2	A	3500	051016	HC	1.50	18.82
239	1968	VOLK	SEDA	91	4	1	4	2000	084309	CO	5.50	0.00
240	1965	CHEV	CHEV	230	6	1	A	3000	071640	PASS	3.50	0.00
241	1965	CHEV	IMPA	396	8	4	A	3500	101402	BOTH	5.00	0.00
242	1970	FORD	MUST	302	8	2	A	3500	016785	HC	3.50	4.50
243	1969	PONT	CATA	400	8	2	A	4000	057823	BOTH	2.50	12.50
245	1968	FORD	FAIR	289	8	2	3	3500	077348	HC	4.50	6.00
246	1968	OLDS	DELT	455	8	2	A	4500	114750	PASS	1.50	0.00
247	1968	FORD	GALA	390	8	2	A	4000	046034	PASS	1.50	0.00
248	1969	PONT	LEMA	350	8	2	A	4000	027997	PASS	5.00	0.00
249	1971	PLYM	FURY	383	8	4	A	4000	030259	PASS	6.00	0.00
250	1970	CHEV	CAME	350	8	2	4	3500	047370	BOTH	2.50	7.50
251	1973	CHEV	IMPA	350	8	4	A	4000	006702	PASS	5.50	0.00
252	1973	OLDS	OMEG	350	8	4	3	3500	009599	PASS	4.00	0.00
254	1970	FORD	MUST	302	8	2	A	3000	036423	PASS	3.50	0.00
255	1972	CHEV	NOVA	307	8	2	A	3000	032867	BOTH	1.50	1.50
256	1966	OLDS	CUTL	330	8	2	A	3500	053077	HC	4.50	41.20
257	1965	CHRY	STAW	413	8	4	A	5000	083241	PASS	5.50	0.00
258	1965	FORD	THUN	390	8	4	A	5000	083016	CO	2.50	2.00
259	1966	VOLK	FAST	97	4	2	4	2250	115141	PASS	5.50	0.00
260	1971	CHRY	IMPE	440	8	4	A	5000	023677	PASS	6.00	0.00
261	1969	FORD	MUST	200	6	1	3	3000	068680	PASS	5.00	0.00
262	1973	CHEV	STAW	454	8	4	A	4500	017416	PASS	5.50	0.00
263	1968	DODG	DART	273	8	2	3	3000	065448	PASS	6.00	0.00
264	1972	OPEL	1900	116	4	2	4	2250	022672	HC	5.50	5.50
265	1969	CHEV	CAPR	327	8	4	A	4000	030213	BOTH	2.50	5.00
266	1967	FORD	MUST	200	6	1	3	3000	064477	CO	4.50	3.00
267	1967	FORD	FALC	200	6	1	3	2750	103550	BOTH	2.50	7.50
268	1973	DODG	DART	225	6	2	A	3000	025094	PASS	6.00	6.00
269	1968	TOYO	CORO	116	4	2	4	2500	061312	PASS	5.50	0.00
270	1971	CHEV	NOVA	250	6	1	A	3500	095217	PASS	5.50	0.00
271	1967	PONT	FIRE	326	8	4	A	3500	059028	PASS	4.00	0.00
272	1966	PLYM	FURY	318	8	2	A	4000	092494	CO	6.00	6.00
273	1970	CHEV	CAPR	400	8	2	A	4000	047305	CO	3.50	4.50
274	1970	BUIC	SKYL	350	8	4	A	4000	034266	PASS	1.50	0.00

AUTOMOTIVE TESTING LABORATORIES, INC.
19900 E. COLFAX, AURORA, COLO. 80011

IDLE INSPECTION EVALUATION VEHICLES

VEH	YEAR	MAKE	MODEL	CID	CYL	CARB	TRAN	I.WT	ODOM.	FAILURE	---COSTS---- INSP.	MTCE.
276	1966	PONT	LEMA	326	8	4	A	3500	073426	BOTH	5.00	1.00
277	1966	FORD	STAW	289	8	2	A	3000	084032	CO	2.50	11.20
278	1965	FORD	MUST	289	8	4	A	3000	059885	PASS	2.50	0.00
279	1973	TOYO	STAW	120	4	2	A	2500	003829	PASS	5.50	0.00
280	1967	CHEV	STAW	327	8	4	3	4000	096491	BOTH	5.50	6.60
281	1966	FORD	MUST	200	6	1	A	3000	059352	PASS	4.50	0.00
282	1968	FORD	FALC	170	6	1	3	3000	097889	PASS	4.00	0.00
283	1968	PONT	CATA	400	8	4	A	4500	075255	PASS	2.50	0.00
284	1971	AMMO	AMBA	401	8	4	A	4000	031837	HC	1.50	40.20
285	1968	PLYM	BARR	318	8	2	A	3500	060568	HC	4.50	4.50
286	1968	DODG	CHAR	318	8	2	A	3500	065609	BOTH	6.00	6.00
287	1971	BUIC	LESA	455	8	4	A	4500	017998	BOTH	2.50	5.00
288	1968	PONT	TEMP	350	8	2	A	3500	040178	CO	3.50	4.00
289	1969	VOLK	SEDA	91	4	1	4	2000	063512	PASS	5.50	0.00
291	1969	PLYM	FURY	318	8	2	A	4000	052667	BOTH	2.50	11.70
292	1971	CHEV	NOVA	307	8	2	A	3500	029533	PASS	5.50	0.00
293	1972	FORD	MUST	351	8	4	A	3500	019843	PASS	1.50	0.00
294	1969	CHRY	NEWP	383	8	2	A	4500	065163	PASS	4.00	0.00
295	1970	DODG	POLA	383	8	2	A	4500	053254	CO	3.50	2.00
296	1965	FORD	MUST	260	8	2	A	3000	052813	BOTH	5.00	2.00
297	1971	PLYM	DUST	198	6	1	3	3000	027784	BOTH	6.00	0.00
298	1972	AMMO	JAVE	360	8	4	4	3500	023737	PASS	5.00	0.00
299	1972	PLYM	SATE	318	8	2	A	3500	028091	BOTH	4.00	0.00
300	1973	OPEL	MANT	116	4	2	4	2250	006817	CO	5.50	11.00
301	1973	MERC	COME	302	8	2	A	3000	010804	BOTH	2.50	7.50
302	1973	BUIC	CENT	350	8	4	A	4000	006508	PASS	5.50	0.00
303	1973	PLYM	DUST	318	8	2	A	3500	006473	PASS	4.50	0.00
304	1972	DODG	CORO	318	8	2	A	3500	022983	PASS	6.00	0.00
305	1969	AMMO	AMBA	290	8	2	A	4000	054001	PASS	2.50	0.00
306	1969	BUIC	ELEC	430	8	4	A	4500	034898	CO	4.50	1.50
307	1969	CHEV	NOVA	230	6	1	A	3000	029124	BOTH	5.50	9.90
308	1969	FORD	TORI	351	8	2	A	3500	021037	PASS	1.50	0.00
309	1969	FORD	TORI	351	8	2	A	3500	074369	BOTH	3.50	2.00
310	1972	FORD	MAVE	302	8	2	A	3000	008455	BOTH	2.50	7.50
311	1972	FORD	MAVE	250	6	1	A	2750	022036	CO	5.00	2.00
312	1972	MERC	COME	302	8	2	A	3000	008589	PASS	4.00	0.00
314	1971	FORD	BRON	302	8	2	3	3500	020440	HC	4.50	36.07
315	1971	OLDS	CUTL	350	8	4	A	3500	026169	PASS	5.50	0.00
316	1970	MERC	MONT	302	8	2	3	3500	027532	HC	2.50	4.00
317	1971	FORD	MAVE	200	6	1	A	2750	023567	PASS	5.00	0.00
318	1971	FORD	GALA	400	8	2	A	4000	040209	BOTH	4.00	0.00
319	1971	FORD	TORI	351	8	2	A	3500	013444	CO	3.50	4.50
320	1973	FORD	MUST	351	8	2	A	3500	003445	PASS	1.50	0.00
321	1970	CHEV	NOVA	250	6	1	A	3500	012130	PASS	6.00	0.00
322	1970	CHEV	NOVA	307	8	2	A	3500	032511	BOTH	2.50	7.50
323	1970	PONT	TEMP	350	8	2	A	3500	030849	BOTH	4.50	21.54
324	1973	CHEV	NOVA	250	6	1	3	3500	004682	PASS	3.50	0.00
325	1973	FORD	GALA	351	8	2	A	4500	016385	PASS	1.50	0.00
326	1969	TOYO	CORO	116	4	2	4	2500	076050	HC	5.50	46.50
327	1970	TOYO	CORO	113	4	2	4	2500	051836	HC	5.50	0.00

EXHAUST EMISSIONS BEFORE INSPECTION

1975 FEDERAL TEST PROCEDURE

	# OF VEH.	HC		CO		NOX		MPG	
		MEAN	S.D.	MEAN	S.D.	MEAN	S.D.	MEAN	S.D.
***VEHICLE MAKE**									
AMER. MOTORS	10	7.33	2.38	102.9	27.9	2.70	1.27	15.00	2.74
BUICK	15	10.01	6.82	148.3	43.4	2.34	1.22	12.01	1.35
CADILLAC	10	6.89	3.81	127.9	60.4	2.69	1.28	10.42	1.35
CHEVROLET	67	8.97	7.04	119.4	63.8	2.29	1.24	13.93	2.68
CHRYSLER	10	11.51	9.14	172.7	67.8	2.11	1.07	10.81	1.34
DATSUN	3	4.21	0.95	41.1	5.0	2.77	1.00	23.41	1.58
DODGE	18	7.28	5.09	102.2	42.8	2.96	1.14	14.94	1.92
FORD	68	7.23	3.93	95.2	35.8	2.98	1.71	14.81	2.94
MERCURY	11	7.84	4.10	99.4	69.6	3.49	2.67	13.56	1.95
OLDSMOBILE	16	7.80	4.38	119.7	40.3	2.36	1.08	12.25	1.14
OPEL	3	4.51	1.54	70.0	29.3	2.19	1.08	21.53	1.00
PLYMOUTH	22	8.38	5.58	123.0	46.2	2.26	1.06	14.33	2.25
PONTIAC	20	9.17	7.29	118.3	64.8	2.67	1.32	12.46	1.30
TOYOTA	6	4.43	1.62	72.8	40.2	2.52	0.96	18.83	2.02
VOLKSWAGON	20	6.36	2.67	81.9	23.4	2.21	0.88	21.36	2.12
VOLVO	1	3.29	0.00	30.9	0.0	4.82	0.00	21.66	0.00
***MODEL YEAR**									
1964	22	10.03	3.29	146.7	58.5	2.13	1.48	14.15	3.54
1965	30	11.92	7.34	148.4	64.1	2.03	1.16	14.10	3.73
1966	29	11.11	7.30	140.6	39.8	2.16	0.91	14.21	2.99
1967	29	9.80	3.07	137.4	47.5	2.16	1.67	14.55	3.23
1968	30	7.21	2.73	113.5	53.2	2.83	1.78	14.28	2.83
1969	29	7.14	6.34	97.5	37.9	3.24	1.30	14.06	2.76
1970	30	6.98	5.09	86.3	40.3	3.37	1.39	14.61	3.24
1971	35	6.45	4.76	82.6	38.6	3.20	1.39	15.09	4.40
1972	33	6.04	5.71	92.6	52.6	2.64	1.08	14.90	3.80
1973	33	4.57	2.01	78.3	33.2	1.99	0.86	15.00	4.03
***DISPLACEMENT**									
LESS THAN 151	39	5.82	2.43	79.2	33.2	2.25	1.00	20.86	2.40
151 - 250	47	6.72	3.50	97.3	43.6	2.40	1.39	17.05	2.30
251 - 350	126	8.97	6.20	117.9	52.2	2.47	1.29	13.58	1.58
MORE THAN 350	88	8.19	6.07	120.2	61.1	3.02	1.63	11.72	1.53
***INERTIA WEIGHT**									
1800 - 2799	46	5.79	2.35	77.9	31.7	2.36	1.26	20.68	2.48
2800 - 3799	127	7.57	4.19	103.6	47.1	2.44	1.25	14.86	2.05
3800 - 4799	112	9.48	7.38	129.0	59.7	2.85	1.62	12.12	1.33
4800 - 5799	15	6.89	3.25	126.6	51.3	2.70	1.18	10.80	1.38
***POPULATIONS**									
1964 - 1967	110	10.77	5.77	143.1	52.5	2.12	1.31	14.26	3.34
1968 - 1973	190	6.36	4.71	91.3	44.1	2.87	1.39	14.68	3.58
ALL VEHICLES	300	7.98	5.54	110.3	53.5	2.59	1.41	14.53	3.49

EXHAUST EMISSIONS AFTER INSPECTION AND MAINTENANCE

1975 FEDERAL TEST PROCEDURE

1964-1967 VEHICLES: 13 HC FAILURES, 13 CO FAILURES, 20.0% FAILURE RATE
1968-1973 VEHICLES: 22 HC FAILURES, 21 CO FAILURES, 20.0% FAILURE RATE

	# OF VEH.	HC		CO		NOX		MPG	
		MEAN	S.D.	MEAN	S.D.	MEAN	S.D.	MEAN	S.D.
*VEHICLE MAKE									
AMER. MOTORS	10	7.07	2.22	100.5	27.3	2.81	1.42	15.13	2.83
BUICK	15	8.63	5.83	145.6	46.9	2.29	1.14	12.09	1.53
CADILLAC	10	6.89	3.81	127.9	60.4	2.69	1.28	10.42	1.35
CHEVROLET	67	8.70	7.26	114.8	58.1	2.25	1.09	14.02	2.57
CHRYSLER	10	7.63	2.60	134.1	43.7	2.37	0.95	11.53	1.34
DATSUN	3	4.21	0.95	41.1	5.0	2.77	1.00	23.41	1.58
DODGE	18	6.66	4.25	97.4	37.9	3.00	1.07	15.11	1.87
FORD	68	6.66	2.80	93.3	35.7	2.96	1.62	14.84	3.09
MERCURY	11	7.93	5.71	107.0	88.3	3.46	2.66	13.12	1.85
OLDSMOBILE	16	9.26	11.44	114.3	37.7	2.41	1.13	12.30	1.34
OPEL	3	4.51	1.54	70.0	29.3	2.19	1.08	21.53	1.00
PLYMOUTH	22	7.07	3.26	116.2	45.2	2.26	1.05	14.59	2.25
PONTIAC	20	7.27	3.77	117.5	65.5	2.70	1.45	12.50	1.20
TOYOTA	6	4.06	1.24	71.9	38.0	2.42	1.10	18.91	1.85
VOLKSWAGON	20	6.00	2.32	81.8	24.0	1.92	0.76	21.40	2.35
VOLVO	1	3.29	0.00	30.9	0.0	4.82	0.00	21.66	0.00
*MODEL YEAR									
1964	22	9.23	3.34	138.1	54.1	2.19	1.58	14.38	3.41
1965	30	11.21	8.21	146.4	62.7	2.04	1.18	14.17	3.76
1966	29	11.30	8.74	142.9	49.7	2.15	0.95	14.18	3.10
1967	29	9.92	4.16	138.3	53.2	2.11	1.67	14.46	3.36
1968	30	6.53	2.31	105.0	37.6	2.69	1.39	14.34	2.59
1969	29	6.82	6.41	91.1	35.2	3.29	1.36	14.21	2.93
1970	30	5.38	1.07	81.6	30.2	3.11	1.21	14.74	3.19
1971	35	5.32	1.34	78.8	34.1	3.31	1.47	15.30	4.53
1972	33	5.09	1.57	84.6	32.6	2.68	1.05	15.00	3.61
1973	33	4.44	1.74	77.7	31.6	2.00	0.86	15.01	4.03
*DISPLACEMENT									
LESS THAN 151	39	5.38	2.05	78.0	32.1	2.09	0.99	20.97	2.55
151 - 250	47	6.63	3.84	96.6	46.4	2.39	1.30	17.08	2.40
251 - 350	126	7.84	4.62	112.5	47.7	2.45	1.20	13.72	1.45
MORE THAN 350	88	7.97	7.23	115.7	58.1	3.07	1.62	11.75	1.49
*INERTIA WEIGHT									
1800 - 2799	46	5.40	2.04	76.4	31.3	2.20	1.17	20.81	2.58
2800 - 3799	127	7.30	4.76	101.5	44.5	2.45	1.21	14.84	2.03
3800 - 4799	112	8.32	6.59	121.8	56.7	2.86	1.57	12.31	1.40
4800 - 5799	15	6.89	3.25	126.6	51.3	2.70	1.18	10.80	1.38
*POPULATIONS									
1964 - 1967	110	10.50	6.70	141.7	54.6	2.12	1.34	14.29	3.38
1968 - 1973	190	5.56	3.00	86.1	34.4	2.84	1.31	14.79	3.56
ALL VEHICLES	300	7.37	5.27	106.5	50.6	2.57	1.36	14.61	3.50

EXHAUST EMISSION REDUCTIONS AFTER INSPECTION AND MAINTENANCE

1975 FEDERAL TEST PROCEDURE

1964-1967 VEHICLES: 13 HC FAILURES, 13 CO FAILURES, 20.0% FAILURE RATE
1968-1973 VEHICLES: 22 HC FAILURES, 21 CO FAILURES, 20.0% FAILURE RATE

	# OF	HC		CO		NOX		MPG	
	VEH.	MEAN	S.D.	MEAN	S.D.	MEAN	S.D.	MEAN	S.D.
*VEHICLE MAKE									
AMER. MOTORS	10	0.259	1.30	2.45	13.34	-0.101	0.29	-0.122	0.61
BUICK	15	1.372	5.65	2.66	10.47	0.054	0.28	-0.082	0.43
CADILLAC	10	0.000	0.00	0.00	0.00	0.000	0.00	0.000	0.00
CHEVROLET	67	0.273	5.05	4.68	25.97	0.046	0.48	-0.093	0.75
CHRYSLER	10	3.886	9.88	38.60	79.89	-0.264	0.60	-0.722	1.47
DATSUN	3	0.000	0.00	0.00	0.00	0.000	0.00	0.000	0.00
DODGE	18	0.619	2.55	4.83	12.81	-0.048	0.20	-0.171	0.42
FORD	68	0.577	2.99	1.90	12.28	0.016	0.70	-0.026	0.69
MERCURY	11	-0.096	1.38	-7.61	22.16	0.039	0.37	0.433	0.83
OLDSMOBILE	16	-1.452	12.74	5.44	27.40	-0.049	0.31	-0.055	0.63
OPEL	3	0.000	0.00	0.00	0.00	0.000	0.00	0.000	0.00
PLYMOUTH	22	1.314	4.93	6.74	14.89	-0.002	0.35	-0.266	0.55
PONTIAC	20	1.902	5.39	0.81	22.22	-0.028	0.32	-0.049	0.46
TOYOTA	6	0.370	0.91	0.39	2.19	0.098	0.24	-0.083	0.20
VOLKSWAGON	20	0.359	0.84	0.08	6.58	0.289	0.71	-0.038	0.58
VOLVO	1	0.000	0.00	0.00	0.00	0.000	0.00	0.000	0.00
*MODEL YEAR									
1964	22	0.797	2.27	8.53	27.36	-0.052	0.33	-0.231	0.77
1965	30	0.714	7.12	1.99	18.55	-0.012	0.19	-0.072	0.41
1966	29	-0.190	10.62	-2.31	19.69	0.016	0.27	0.032	0.65
1967	29	-0.121	1.91	-0.92	12.99	0.049	0.38	0.084	0.66
1968	30	0.673	1.99	8.47	34.72	0.142	0.77	-0.060	1.03
1969	29	0.327	0.71	6.41	16.95	-0.053	0.50	-0.153	0.39
1970	30	1.592	4.79	4.80	21.12	0.253	0.97	-0.128	0.91
1971	35	1.131	4.23	3.86	11.08	-0.105	0.41	-0.208	0.60
1972	33	0.949	5.50	7.94	43.12	-0.035	0.36	-0.097	0.80
1973	33	0.133	0.77	0.62	3.58	-0.002	0.01	-0.017	0.10
*DISPLACEMENT									
LESS THAN 151	39	0.442	1.08	1.24	6.59	0.165	0.53	-0.106	0.56
151 - 250	47	0.096	2.14	0.74	12.18	0.017	0.14	-0.035	0.65
251 - 350	126	1.128	4.30	5.34	20.76	0.018	0.46	-0.132	0.66
MORE THAN 350	88	0.215	7.33	4.53	34.00	-0.042	0.63	-0.029	0.74
*INERTIA WEIGHT									
1800 - 2799	46	0.390	1.01	1.51	6.74	0.160	0.50	-0.128	0.57
2800 - 3799	127	0.271	3.57	2.13	15.52	-0.009	0.50	0.019	0.63
3800 - 4799	112	1.164	7.10	7.28	34.14	-0.005	0.52	-0.192	0.78
4800 - 5799	15	0.000	0.00	0.00	0.00	0.000	0.00	0.000	0.00
*POPULATIONS									
1964 - 1967	110	0.272	6.68	1.39	19.71	0.002	0.30	-0.035	0.63
1968 - 1973	190	0.804	3.58	5.27	25.26	0.029	0.58	-0.111	0.70
ALL VEHICLES	300	0.609	4.94	3.85	23.42	0.019	0.50	-0.083	0.67

AUTOMOTIVE TESTING LABORATORIES, INC.
19900 E. COLFAX, AURORA, COLO. 80011

PERCENT REDUCTIONS AND REDUCTIONS PER DOLLAR

1975 FEDERAL TEST PROCEDURE

1964-1967 VEHICLES: 13 HC FAILURES, 13 CO FAILURES, 20.0% FAILURE RATE
1968-1973 VEHICLES: 22 HC FAILURES, 21 CO FAILURES, 20.0% FAILURE RATE

	# OF	------PERCENT REDUCTIONS------				MILLIGRAMS/MILE/DOLLAR		
	VEH.	HC	CO	NOX	MPG	HC	CO	NOX
*VEHICLE MAKE								
AMER. MOTORS	10	3.53	2.38	-3.84	-0.81	34.9	330.7	-14.0
BUICK	15	13.71	1.79	2.28	-0.68	161.7	313.3	6.3
CADILLAC	10	0.00	0.00	0.00	0.00	0.0	0.0	0.0
CHEVROLET	67	3.04	3.92	2.02	-0.67	46.4	795.8	7.9
CHRYSLER	10	33.76	22.36	-12.50	-6.67	285.3	2833.9	-19.4
DATSUN	3	0.00	0.00	0.00	0.00	0.0	0.0	0.0
DODGE	18	8.51	4.73	-1.61	-1.15	104.7	816.7	-8.0
FORD	68	7.97	1.99	0.52	-0.18	84.7	278.6	2.3
MERCURY	11	-1.23	-7.65	0.85	3.19	-10.4	-823.9	3.2
OLDSMOBILE	16	-18.60	4.54	-2.06	-0.45	-178.4	668.1	-6.0
OPEL	3	0.00	0.00	0.00	0.00	0.0	0.0	0.0
PLYMOUTH	22	15.68	5.48	-0.11	-1.85	163.5	[illegible]	-0.3
PONTIAC	20	20.75	0.69	-1.04	-0.39	206.7	[illegible]	-3.0
TOYOTA	6	8.36	1.23	3.90	-0.44	28.0	67.5	7.4
VOLKSWAGON	20	5.65	0.10	13.09	-0.18	58.4	12.8	47.0
VOLVO	1	0.00	0.00	0.00	0.00	0.0	0.0	0.0
*MODEL YEAR								
1964	22	7.95	5.82	-2.43	-1.64	94.1	1006.4	-6.1
1965	30	5.99	1.34	-0.91	-0.51	98.4	273.5	-2.5
1966	29	-1.71	-1.65	0.73	0.22	-25.1	-305.3	2.1
1967	29	-1.23	-0.67	2.29	0.57	-24.0	-182.9	9.8
1968	30	9.34	7.46	5.00	-0.42	72.4	910.6	15.2
1969	29	4.58	6.58	-1.64	-1.09	50.7	992.9	-8.2
1970	30	22.83	5.56	7.66	-0.87	168.9	509.0	27.4
1971	35	17.54	4.67	-3.27	-1.38	130.3	444.6	-12.1
1972	33	15.71	8.58	-1.33	-0.65	170.7	1428.4	-6.3
1973	33	2.92	0.80	-0.12	-0.11	27.2	127.1	-0.5
*DISPLACEMENT								
LESS THAN 151	39	7.59	1.57	7.32	-0.51	57.3	161.0	21.4
151 - 250	47	1.43	0.76	0.73	-0.21	20.0	155.0	3.6
251 - 350	126	12.58	4.53	0.71	-0.97	157.7	746.7	2.5
MORE THAN 350	88	2.62	3.77	-1.40	-0.25	25.5	538.2	-5.0
*INERTIA WEIGHT								
1800 - 2799	46	6.33	1.94	6.78	-0.62	54.7	211.6	22.4
2800 - 3799	127	3.58	2.05	-0.35	0.13	44.3	347.6	-1.4
3800 - 4799	112	12.28	5.64	-0.17	-1.58	128.4	803.1	-0.5
4800 - 5799	15	0.00	0.00	0.00	0.00	0.0	0.0	0.0
*POPULATIONS								
1964 - 1967	110	2.53	0.97	0.09	-0.25	38.9	199.2	0.3
1968 - 1973	190	12.64	5.77	1.02	-0.76	109.3	716.4	4.0
ALL VEHICLES	300	7.63	3.49	0.74	-0.57	84.3	532.7	2.6

EXHAUST EMISSIONS AFTER INSPECTION AND MAINTENANCE

1975 FEDERAL TEST PROCEDURE

1964-1967 VEHICLES: 20 HC FAILURES, 21 CO FAILURES, 30.9% FAILURE RATE
1968-1973 VEHICLES: 36 HC FAILURES, 34 CO FAILURES, 30.5% FAILURE RATE

	# OF	HC		CO		NOX		MPG	
	VEH.	MEAN	S.D.	MEAN	S.D.	MEAN	S.D.	MEAN	S.D.
*VEHICLE MAKE									
AMER. MOTORS	10	6.85	2.29	97.5	27.2	2.81	1.42	15.47	3.47
BUICK	15	8.48	5.84	141.4	44.4	2.31	1.12	12.18	1.51
CADILLAC	10	6.73	3.63	127.0	58.9	2.67	1.30	10.47	1.33
CHEVROLET	67	8.02	6.25	110.5	58.5	2.22	1.13	14.05	2.44
CHRYSLER	10	7.63	2.60	134.1	43.7	2.37	0.95	11.53	1.34
DATSUN	3	4.21	0.95	42.5	6.0	2.54	0.76	23.33	1.69
DODGE	18	6.45	4.28	92.9	40.0	2.88	1.00	15.30	1.94
FORD	68	6.66	2.73	93.2	35.2	2.96	1.62	14.83	3.05
MERCURY	11	7.93	5.21	107.0	88.3	3.46	2.66	13.12	1.85
OLDSMOBILE	16	9.19	11.46	111.5	38.6	2.42	1.13	12.34	1.39
OPEL	3	4.51	1.54	70.0	29.3	2.19	1.08	21.53	1.00
PLYMOUTH	22	6.79	2.90	112.4	44.0	2.32	1.14	14.71	2.34
PONTIAC	20	7.16	3.83	115.9	66.0	2.71	1.46	12.56	1.23
TOYOTA	6	3.82	1.03	67.2	41.2	2.50	1.17	19.10	1.86
VOLKSWAGON	20	5.88	2.25	81.2	23.7	1.92	0.76	21.46	2.37
VOLVO	1	3.29	0.00	30.9	0.0	4.82	0.00	21.66	0.00
*MODEL YEAR									
1964	22	9.23	3.34	138.1	54.1	2.19	1.58	14.38	3.41
1965	30	10.88	8.26	144.7	61.1	2.01	1.20	14.23	3.76
1966	29	11.05	8.81	138.8	52.0	2.09	0.84	14.33	3.12
1967	29	9.95	4.15	139.1	52.3	2.07	1.69	14.46	3.35
1968	30	6.41	2.24	101.5	33.7	2.70	1.37	14.43	2.54
1969	29	5.61	1.43	84.5	28.8	3.31	1.42	14.34	2.81
1970	30	5.22	1.09	79.4	32.0	3.12	1.21	14.70	3.22
1971	35	5.17	1.32	76.2	34.9	3.28	1.47	15.40	4.56
1972	33	5.01	1.53	82.3	32.8	2.71	1.11	15.06	3.67
1973	33	4.44	1.74	77.7	31.6	2.00	0.86	15.01	4.03
*DISPLACEMENT									
LESS THAN 151	39	5.22	1.97	76.6	32.5	2.09	0.98	21.07	2.52
151 - 250	47	6.56	3.88	96.1	47.7	2.36	1.34	17.05	2.44
251 - 350	126	7.38	3.61	107.8	46.9	2.44	1.21	13.82	1.42
MORE THAN 350	88	7.95	7.23	115.6	57.9	3.07	1.62	11.76	1.48
*INERTIA WEIGHT									
1800 - 2799	46	5.24	1.94	75.8	31.8	2.19	1.17	20.82	2.59
2800 - 3799	127	7.16	4.78	98.9	45.0	2.42	1.21	14.91	2.10
3800 - 4799	112	7.95	5.87	119.0	56.0	2.87	1.58	12.37	1.38
4800 - 5799	15	6.79	3.12	126.1	50.2	2.69	1.20	10.83	1.36
*POPULATIONS									
1964 - 1967	110	10.35	6.72	140.4	54.4	2.08	1.33	14.35	3.38
1968 - 1973	190	5.29	1.68	83.3	33.1	2.84	1.32	14.85	3.56
ALL VEHICLES	300	7.14	4.92	104.2	50.3	2.57	1.37	14.66	3.50

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EXHAUST EMISSION REDUCTIONS AFTER INSPECTION AND MAINTENANCE

1975 FEDERAL TEST PROCEDURE

1964-1967 VEHICLES: 20 HC FAILURES, 21 CO FAILURES, 30.9% FAILURE RATE
1968-1973 VEHICLES: 36 HC FAILURES, 34 CO FAILURES, 30.5% FAILURE RATE

	# OF VEH.	HC MEAN	HC S.D.	CO MEAN	CO S.D.	NOX MEAN	NOX S.D.	MPG MEAN	MPG S.D.
*VEHICLE MAKE									
AMER. MOTORS	10	0.475	1.42	5.50	15.94	-0.104	0.29	-0.462	1.20
BUICK	15	1.527	5.64	6.88	18.79	0.033	0.30	-0.171	0.54
CADILLAC	10	0.164	0.52	0.86	2.73	0.021	0.06	-0.053	0.17
CHEVROLET	67	0.953	6.43	8.93	32.48	0.070	0.71	-0.122	0.99
CHRYSLER	10	3.886	9.88	38.60	79.89	-0.264	0.60	-0.722	1.47
DATSUN	3	0.004	0.01	-1.47	2.54	0.235	0.41	0.086	0.15
DODGE	18	0.830	2.56	9.34	16.84	0.072	0.56	-0.360	0.65
FORD	68	0.570	3.03	1.99	13.86	0.018	0.71	-0.022	0.73
MERCURY	11	-0.096	1.38	-7.61	22.16	0.030	0.37	0.433	0.83
OLDSMOBILE	16	-1.382	12.25	8.20	28.99	-0.062	0.31	-0.092	0.65
OPEL	3	0.000	0.00	0.00	0.00	0.000	0.00	0.000	0.00
PLYMOUTH	22	1.586	4.94	10.59	16.62	-0.059	0.43	-0.377	0.65
PONTIAC	20	2.005	5.31	2.40	24.96	-0.031	0.35	-0.107	0.57
TOYOTA	6	0.611	0.98	5.63	11.37	0.020	0.34	-0.268	0.46
VOLKSWAGON	20	0.482	0.96	0.72	7.16	0.284	0.72	-0.100	0.64
VOLVO	1	0.000	0.00	0.00	0.00	0.000	0.00	0.000	0.00
*MODEL YEAR									
1964	22	0.797	2.27	8.53	27.36	-0.052	0.33	-0.231	0.77
1965	30	1.043	7.14	3.72	20.95	0.013	0.24	-0.130	1.01
1966	29	0.070	10.66	1.77	23.69	0.069	0.49	-0.114	0.81
1967	29	-0.146	2.10	-1.73	14.73	0.090	0.40	0.088	0.80
1968	30	0.795	1.92	11.96	36.58	0.135	0.78	-0.146	1.06
1969	29	1.537	6.09	12.92	31.67	-0.077	0.92	-0.284	0.67
1970	30	1.754	4.76	6.92	21.65	0.249	0.98	-0.086	0.98
1971	35	1.280	4.22	6.46	14.03	-0.076	0.44	-0.312	0.68
1972	33	1.030	5.50	10.25	43.64	-0.069	0.41	-0.155	0.84
1973	33	0.133	0.77	0.62	3.58	-0.002	0.01	-0.017	0.10
*DISPLACEMENT									
LESS THAN 151	39	0.598	1.16	2.59	8.41	0.167	0.55	-0.205	0.66
151 - 250	47	0.159	2.23	1.20	16.30	0.046	0.31	-0.000	1.05
251 - 350	126	1.583	5.15	10.03	26.24	0.024	0.62	-0.240	0.77
MORE THAN 350	88	0.233	7.33	4.60	34.00	-0.041	0.63	-0.037	0.75
*INERTIA WEIGHT									
1800 - 2799	46	0.553	1.09	2.02	9.47	0.168	0.52	-0.137	0.85
2800 - 3799	127	0.406	3.61	4.69	18.57	0.019	0.57	-0.050	0.80
3800 - 4799	112	1.538	7.71	10.08	37.31	-0.019	0.64	-0.253	0.84
4800 - 5799	15	0.109	0.42	0.58	2.23	0.014	0.05	-0.035	0.14
*POPULATIONS									
1964 - 1967	110	0.424	6.72	2.73	21.76	0.035	0.38	-0.089	0.85
1968 - 1973	190	1.075	4.27	8.03	28.34	0.023	0.67	-0.167	0.78
ALL VEHICLES	300	0.836	5.30	6.09	26.21	0.027	0.58	-0.138	0.80

PERCENT REDUCTIONS AND REDUCTIONS PER DOLLAR

1975 FEDERAL TEST PROCEDURE

1964-1967 VEHICLES: 20 HC FAILURES, 21 CO FAILURES, 30.9% FAILURE RATE
1968-1973 VEHICLES: 36 HC FAILURES, 34 CO FAILURES, 30.5% FAILURE RATE

	# OF	------PERCENT REDUCTIONS------				MILLIGRAMS/MILE/DOLLAR		
	VEH.	HC	CO	NOX	MPG	HC	CO	NOX
*VEHICLE MAKE								
AMER. MOTORS	10	6.48	5.34	-3.80	-3.08	61.5	712.2	-13.5
BUICK	15	15.27	4.64	1.39	-1.42	171.2	771.3	3.6
CADILLAC	10	2.37	0.68	0.76	-0.51	44.8	236.6	5.6
CHEVROLET	67	10.62	7.47	3.04	-0.87	118.6	1110.9	8.7
CHRYSLER	10	33.76	22.36	-12.50	-6.67	285.3	2833.9	-19.4
DATSUN	3	0.08	-3.57	8.47	0.37	0.5	-200.1	32.0
DODGE	18	11.41	9.14	2.44	-2.41	123.0	1383.8	10.7
FORD	68	7.88	2.09	0.62	-0.15	80.9	282.1	2.6
MERCURY	11	-1.23	-7.65	0.85	3.19	-10.4	-823.8	3.2
OLDSMOBILE	16	-17.70	6.85	-2.62	-0.75	-162.3	962.9	-7.3
OPEL	3	0.00	0.00	0.00	0.00	0.0	0.0	0.0
PLYMOUTH	22	18.93	8.61	-2.63	-2.63	171.2	1143.2	-6.4
PONTIAC	20	21.87	2.03	-1.17	-0.86	190.4	227.8	-3.0
TOYOTA	6	13.77	7.74	0.78	-1.43	46.1	425.2	1.5
VOLKSWAGON	20	7.58	0.87	12.89	-0.47	77.1	114.5	45.5
VOLVO	1	0.00	0.00	0.00	0.00	0.0	0.0	0.0
*MODEL YEAR								
1964	22	7.95	5.82	-2.43	-1.64	94.1	1006.4	-6.1
1965	30	8.75	2.51	0.62	-0.92	129.7	462.4	1.6
1966	29	0.63	1.26	3.20	-0.80	8.5	215.0	8.4
1967	29	-1.49	-1.26	4.19	0.60	-22.7	-268.1	14.0
1968	30	11.04	10.54	4.78	-1.03	81.8	1229.9	13.9
1969	29	21.52	13.25	-2.37	-2.02	158.3	1330.5	-7.9
1970	30	25.14	8.02	7.40	-0.59	172.8	682.1	24.6
1971	35	19.85	7.82	-2.38	-2.07	137.6	695.1	-8.2
1972	33	17.05	11.08	-2.61	-1.04	165.5	1647.7	-11.1
1973	33	2.92	0.80	-0.17	-0.11	27.2	127.1	-0.5
*DISPLACEMENT								
LESS THAN 151	39	10.27	3.27	7.41	-0.98	74.1	321.0	20.7
151 - 250	47	2.37	1.24	1.93	-0.00	28.0	211.5	8.1
251 - 350	126	17.66	8.51	0.98	-1.77	181.9	1153.0	2.8
MORE THAN 350	88	2.85	3.82	-1.35	-0.31	27.6	543.4	-4.8
*INERTIA WEIGHT								
1800 - 2799	46	9.55	2.60	7.14	-0.66	72.8	266.5	22.2
2800 - 3799	127	5.36	4.52	0.76	-0.34	57.4	663.0	2.6
3800 - 4799	112	16.22	7.82	-0.68	-2.09	153.2	1004.1	-1.9
4800 - 5799	15	1.58	0.45	0.51	-0.33	32.1	169.4	4.0
*POPULATIONS								
1964 - 1967	110	3.93	1.91	1.66	-0.62	54.7	352.2	4.5
1968 - 1973	190	16.90	8.79	0.79	-1.14	130.1	971.8	2.7
ALL VEHICLES	300	10.48	5.52	1.05	-0.95	103.5	753.8	3.4

EXHAUST EMISSIONS AFTER INSPECTION AND MAINTENANCE

1975 FEDERAL TEST PROCEDURE

1964-1967 VEHICLES: 28 HC FAILURES, 25 CO FAILURES, 39.1% FAILURE RATE
1968-1973 VEHICLES: 47 HC FAILURES, 48 CO FAILURES, 40.0% FAILURE RATE

	# OF	HC		CO		NOX		MPG	
	VEH.	MEAN	S.D.	MEAN	S.D.	MEAN	S.D.	MEAN	S.D.
*VEHICLE MAKE									
AMER. MOTORS	10	6.59	1.95	94.6	23.4	2.79	1.41	15.53	3.41
BUICK	15	8.42	5.85	141.1	45.2	2.24	1.18	12.16	1.46
CADILLAC	10	6.73	3.63	127.0	58.9	2.67	1.30	10.47	1.33
CHEVROLET	67	8.00	6.26	110.4	58.9	2.21	1.13	14.06	2.46
CHRYSLER	10	6.91	1.80	121.3	32.5	2.49	1.00	11.64	1.22
DATSUN	3	4.21	0.95	42.5	6.0	2.54	0.76	23.33	1.69
DODGE	18	6.48	4.28	92.6	39.9	2.89	1.00	15.30	1.94
FORD	68	6.59	2.73	91.9	34.8	2.88	1.51	14.90	3.05
MERCURY	11	7.93	5.21	107.0	88.3	3.46	2.66	13.12	1.85
OLDSMOBILE	16	9.25	11.44	109.6	38.8	2.42	1.13	12.32	1.39
OPEL	3	4.11	1.58	63.8	28.6	2.20	1.07	21.59	1.01
PLYMOUTH	22	6.70	2.95	109.3	43.3	2.32	1.14	14.78	2.26
PONTIAC	20	7.19	3.81	113.4	67.6	2.85	1.49	12.71	1.28
TOYOTA	6	3.82	1.03	67.2	41.2	2.50	1.17	19.10	1.86
VOLKSWAGON	20	5.86	2.24	81.0	23.6	1.93	0.80	21.42	2.42
VOLVO	1	3.29	0.00	30.9	0.0	4.82	0.00	21.66	0.00
*MODEL YEAR									
1964	22	9.34	3.37	138.1	54.2	2.19	1.59	14.39	3.41
1965	30	10.90	8.25	144.8	61.0	2.00	1.20	14.23	3.77
1966	29	10.87	8.85	136.8	53.6	2.08	0.87	14.41	3.12
1967	29	9.85	4.17	138.2	52.4	2.05	1.69	14.49	3.35
1968	30	6.32	2.18	99.0	32.3	2.74	1.38	14.44	2.55
1969	29	5.55	1.38	82.7	28.5	3.25	1.26	14.48	2.75
1970	30	5.26	1.12	78.4	31.1	3.12	1.20	14.69	3.23
1971	35	5.16	1.32	76.2	34.9	3.23	1.39	15.41	4.56
1972	33	4.92	1.50	79.7	30.2	2.69	1.10	15.13	3.65
1973	33	4.24	1.11	74.6	24.8	2.03	0.87	15.01	4.00
*DISPLACEMENT									
LESS THAN 151	39	5.18	1.98	76.1	32.5	2.09	1.00	21.05	2.54
151 - 250	47	6.57	3.88	95.6	47.7	2.35	1.33	17.07	2.44
251 - 350	126	7.33	3.62	106.8	46.9	2.40	1.15	13.85	1.43
MORE THAN 350	88	7.85	7.21	112.7	57.4	3.09	1.59	11.83	1.52
*INERTIA WEIGHT									
1800 - 2799	46	5.20	1.95	75.0	31.8	2.18	1.18	20.83	2.57
2800 - 3799	127	7.11	4.79	97.9	44.7	2.38	1.15	14.95	2.09
3800 - 4799	112	7.86	5.84	116.6	55.8	2.89	1.57	12.41	1.39
4800 - 5799	15	6.79	3.12	126.1	50.2	2.69	1.20	10.83	1.36
*POPULATIONS									
1964 - 1967	110	10.30	6.73	139.6	54.9	2.07	1.34	14.38	3.38
1968 - 1973	190	5.22	1.58	81.5	31.1	2.84	1.27	14.88	3.54
ALL VEHICLES	300	7.08	4.91	102.8	50.0	2.56	1.35	14.70	3.49

EXHAUST EMISSION REDUCTIONS AFTER INSPECTION AND MAINTENANCE

1975 FEDERAL TEST PROCEDURE

1964-1967 VEHICLES: 28 HC FAILURES, 25 CO FAILURES, 39.1% FAILURE RATE
1968-1973 VEHICLES: 47 HC FAILURES, 48 CO FAILURES, 40.0% FAILURE RATE

	# OF	HC		CO		NOX		MPG	
	VEH.	MEAN	S.D.	MEAN	S.D.	MEAN	S.D.	MEAN	S.D.
*VEHICLE MAKE									
AMER. MOTORS	10	0.738	1.56	8.37	17.36	-0.091	0.30	-0.530	1.19
BUICK	15	1.582	5.63	7.17	19.39	0.100	0.38	-0.154	0.59
CADILLAC	10	0.164	0.52	0.86	2.73	0.021	0.06	-0.053	0.17
CHEVROLET	67	0.972	6.44	9.04	32.69	0.081	0.71	-0.130	1.00
CHRYSLER	10	4.599	9.71	51.37	77.66	-0.385	0.61	-0.830	1.43
DATSUN	3	0.004	0.01	-1.47	2.54	0.235	0.41	0.086	0.15
DODGE	18	0.803	2.57	9.61	16.72	0.068	0.56	-0.359	0.66
FORD	68	0.639	3.09	3.27	15.25	0.097	0.82	-0.086	0.78
MERCURY	11	-0.096	1.38	-7.61	22.16	0.030	0.37	0.433	0.83
OLDSMOBILE	16	-1.449	12.25	10.14	29.44	-0.065	0.31	-0.075	0.65
OPEL	3	0.406	0.70	6.18	10.70	-0.003	0.00	-0.061	0.10
PLYMOUTH	22	1.684	4.92	13.66	18.12	-0.062	0.43	-0.448	0.72
PONTIAC	20	1.981	5.32	4.94	26.72	-0.174	0.59	-0.251	0.95
TOYOTA	6	0.611	0.98	5.63	11.37	0.020	0.34	-0.268	0.46
VOLKSWAGON	20	0.497	0.96	0.86	7.78	0.280	0.75	-0.065	0.67
VOLVO	1	0.000	0.00	0.00	0.00	0.000	0.00	0.000	0.00
*MODEL YEAR									
1964	22	0.695	2.38	8.55	27.42	-0.055	0.34	-0.238	0.79
1965	30	1.025	7.15	3.66	21.04	0.029	0.26	-0.135	1.01
1966	29	0.241	10.68	3.82	25.56	0.085	0.51	-0.195	0.87
1967	29	-0.050	2.16	-0.83	15.79	0.109	0.40	0.056	0.81
1968	30	0.883	1.95	14.44	37.54	0.095	0.81	-0.162	1.08
1969	29	1.591	6.08	14.76	32.09	-0.018	1.19	-0.418	0.88
1970	30	1.718	4.78	7.96	22.05	0.248	0.98	-0.077	0.98
1971	35	1.285	4.22	6.42	14.06	-0.030	0.49	-0.321	0.68
1972	33	1.124	5.49	12.87	44.02	-0.053	0.42	-0.224	0.90
1973	33	0.339	1.15	3.74	13.49	-0.036	0.14	-0.011	0.19
*DISPLACEMENT									
LESS THAN 151	39	0.637	1.16	3.14	9.02	0.165	0.57	-0.192	0.68
151 - 250	47	0.156	2.23	1.74	16.52	0.051	0.31	-0.021	1.06
251 - 350	126	1.642	5.16	11.09	26.52	0.066	0.69	-0.267	0.79
MORE THAN 350	88	0.341	7.36	7.46	35.89	-0.069	0.70	-0.108	0.87
*INERTIA WEIGHT									
1800 - 2799	46	0.588	1.09	2.90	10.24	0.173	0.54	-0.146	0.87
2800 - 3799	127	0.457	3.64	5.70	19.32	0.053	0.64	-0.089	0.83
3800 - 4799	112	1.628	7.72	12.42	38.31	-0.034	0.70	-0.296	0.90
4800 - 5799	15	0.109	0.42	0.58	2.23	0.014	0.05	-0.035	0.14
*POPULATIONS									
1964 - 1967	110	0.469	6.74	3.50	22.46	0.048	0.39	-0.121	0.88
1968 - 1973	190	1.144	4.28	9.86	29.25	0.030	0.74	-0.201	0.83
ALL VEHICLES	300	0.897	5.31	7.53	27.10	0.037	0.63	-0.172	0.85

PERCENT REDUCTIONS AND REDUCTIONS PER DOLLAR

1975 FEDERAL TEST PROCEDURE

1964-1967 VEHICLES: 28 HC FAILURES, 25 CO FAILURES, 39.1% FAILURE RATE
1968-1973 VEHICLES: 47 HC FAILURES, 48 CO FAILURES, 40.0% FAILURE RATE

	# OF	PERCENT REDUCTIONS				MILLIGRAMS/MILE/DOLLAR		
	VEH.	HC	CO	NOX	MPG	HC	CO	NOX
*VEHICLE MAKE								
AMER. MOTORS	10	10.06	8.13	-3.36	-3.53	87.1	988.2	-10.7
BUICK	15	15.81	4.83	4.27	-1.28	156.1	706.9	9.9
CADILLAC	10	2.37	0.68	0.76	-0.51	44.8	236.6	5.6
CHEVROLET	67	10.84	7.57	3.55	-0.94	107.0	995.1	9.0
CHRYSLER	10	39.96	29.75	-18.25	-7.68	271.1	3027.7	-22.7
DATSUN	3	0.08	-3.57	8.47	0.37	0.5	-200.1	32.0
DODGE	18	11.02	9.40	2.29	-2.40	113.3	1356.4	9.6
FORD	68	8.83	3.44	3.25	-0.58	82.5	422.9	12.5
MERCURY	11	-1.23	-7.65	0.85	3.19	-10.4	-823.8	3.2
OLDSMOBILE	16	-18.57	8.47	-2.74	-0.61	-167.8	1173.8	-7.5
OPEL	3	8.99	8.83	-0.13	-0.28	44.2	674.2	-0.3
PLYMOUTH	22	20.09	11.11	-2.73	-3.13	176.6	1432.8	-6.5
PONTIAC	20	21.60	4.17	-6.50	-2.02	173.3	432.0	-15.2
TOYOTA	6	13.77	7.74	0.78	-1.43	46.1	425.2	1.5
VOLKSWAGON	20	7.82	1.06	12.70	-0.31	70.3	122.2	39.6
VOLVO	1	0.00	0.00	0.00	0.00	0.0	0.0	0.0
*MODEL YEAR								
1964	22	6.93	5.83	-2.56	-1.68	78.9	970.5	-6.2
1965	30	8.60	2.47	1.45	-0.96	119.8	428.1	3.4
1966	29	2.17	2.72	3.93	-1.38	25.7	406.3	9.0
1967	29	-0.51	-0.60	5.04	0.38	-7.2	-119.2	15.7
1968	30	12.25	12.72	3.34	-1.13	71.0	1161.7	7.6
1969	29	22.27	15.14	-0.55	-2.97	154.6	1433.5	-1.7
1970	30	24.63	9.22	7.35	-0.53	168.2	779.0	24.3
1971	35	19.92	7.76	-0.95	-2.13	136.3	680.5	-3.2
1972	33	18.60	13.91	-2.00	-1.50	168.0	1923.7	-7.9
1973	33	7.41	4.78	-1.79	-0.07	54.3	600.1	-5.7
*DISPLACEMENT								
LESS THAN 151	39	10.94	3.96	7.31	-0.92	72.6	358.1	18.8
151 - 250	47	2.32	1.79	2.12	-0.12	26.7	298.4	8.7
251 - 350	126	18.31	9.41	2.69	-1.97	177.3	1197.1	7.2
MORE THAN 350	88	4.16	6.21	-2.29	-0.92	34.2	749.4	-7.0
*INERTIA WEIGHT								
1800 - 2799	46	10.15	3.73	7.33	-0.71	71.3	352.3	21.0
2800 - 3799	127	6.03	5.50	2.17	-0.60	60.6	756.5	7.0
3800 - 4799	112	17.17	9.63	-1.18	-2.44	143.4	1094.1	-3.0
4800 - 5799	15	1.58	0.45	0.51	-0.33	32.1	169.4	4.0
*POPULATIONS								
1964 - 1967	110	4.35	2.45	2.28	-0.85	55.8	416.4	5.7
1968 - 1973	190	17.99	10.79	1.06	-1.37	125.3	1079.7	3.3
ALL VEHICLES	300	11.24	6.82	1.42	-1.18	101.2	849.1	4.2

EXHAUST EMISSIONS AFTER INSPECTION AND MAINTENANCE

1975 FEDERAL TEST PROCEDURE

1964-1967 VEHICLES: 37 HC FAILURES, 36 CO FAILURES, 50.0% FAILURE RATE
1968-1973 VEHICLES: 61 HC FAILURES, 64 CO FAILURES, 50.0% FAILURE RATE

	# OF	HC		CO		NOX		MPG	
	VEH.	MEAN	S.D.	MEAN	S.D.	MEAN	S.D.	MEAN	S.D.
*VEHICLE MAKE									
AMER. MOTORS	10	6.59	1.95	94.6	23.4	2.79	1.41	15.53	3.41
BUICK	15	8.34	5.88	138.7	45.4	2.25	1.21	12.23	1.45
CADILLAC	10	6.73	3.63	127.0	58.9	2.67	1.30	10.47	1.33
CHEVROLET	67	7.68	5.82	106.1	53.9	2.23	1.13	14.16	2.37
CHRYSLER	10	6.91	1.80	121.3	32.5	2.49	1.00	11.64	1.22
DATSUN	3	4.21	0.95	42.5	6.0	2.54	0.76	23.33	1.69
DODGE	18	6.70	4.36	96.7	40.6	2.82	1.02	15.22	1.98
FORD	68	6.46	2.50	91.0	34.6	2.89	1.49	14.90	3.10
MERCURY	11	7.82	5.19	96.7	85.8	3.61	2.58	13.32	1.90
OLDSMOBILE	16	9.25	11.44	109.6	38.8	2.42	1.13	12.32	1.39
OPEL	3	4.11	1.58	63.8	28.6	2.20	1.07	21.59	1.01
PLYMOUTH	22	6.67	2.96	108.3	44.5	2.33	1.15	14.73	2.26
PONTIAC	20	7.20	3.81	113.4	67.5	2.84	1.49	12.70	1.28
TOYOTA	6	3.53	0.65	64.6	42.9	2.39	1.19	19.70	2.96
VOLKSWAGON	20	5.65	2.05	78.5	22.1	1.91	0.80	21.69	2.38
VOLVO	1	3.29	0.00	30.9	0.0	4.82	0.00	21.66	0.00
*MODEL YEAR									
1964	22	9.27	3.39	136.9	53.0	2.18	1.60	14.47	3.39
1965	30	10.29	7.72	139.6	53.7	2.07	1.19	14.32	3.72
1966	29	10.82	8.89	136.0	54.1	2.05	0.89	14.57	3.42
1967	29	9.63	3.92	134.4	51.6	2.09	1.68	14.56	3.32
1968	30	6.31	2.15	98.4	31.8	2.73	1.38	14.47	2.55
1969	29	5.47	1.29	81.3	29.9	3.22	1.26	14.57	2.81
1970	30	5.25	1.12	77.8	30.3	3.14	1.19	14.68	3.24
1971	35	5.07	1.34	74.4	34.1	3.22	1.39	15.58	4.78
1972	33	4.89	1.52	79.2	30.4	2.71	1.10	15.06	3.59
1973	33	4.21	1.11	73.4	25.1	2.02	0.83	14.96	4.00
*DISPLACEMENT									
LESS THAN 151	39	5.03	1.84	74.4	32.2	2.07	0.99	21.28	2.62
151 - 250	47	6.55	3.88	94.7	46.4	2.33	1.34	17.14	2.38
251 - 350	126	7.10	3.08	103.9	43.5	2.42	1.12	13.89	1.37
MORE THAN 350	88	7.85	7.22	112.3	57.4	3.10	1.59	11.82	1.51
*INERTIA WEIGHT									
1800 - 2799	46	5.07	1.84	73.5	31.5	2.17	1.18	21.02	2.65
2800 - 3799	127	7.02	4.72	96.2	43.4	2.38	1.14	14.99	2.06
3800 - 4799	112	7.70	5.57	114.6	53.6	2.91	1.55	12.44	1.38
4800 - 5799	15	6.76	3.14	125.8	50.5	2.68	1.19	10.80	1.34
*POPULATIONS									
1964 - 1967	110	10.05	6.53	136.7	52.4	2.09	1.34	14.48	3.43
1968 - 1973	190	5.18	1.57	80.4	31.1	2.83	1.27	14.91	3.59
ALL VEHICLES	300	6.96	4.76	101.1	48.5	2.56	1.34	14.75	3.53

AUTOMOTIVE TESTING LABORATORIES, INC.
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EXHAUST EMISSION REDUCTIONS AFTER INSPECTION AND MAINTENANCE

1975 FEDERAL TEST PROCEDURE

1964-1967 VEHICLES: 37 HC FAILURES, 36 CO FAILURES, 50.0% FAILURE RATE
1968-1973 VEHICLES: 61 HC FAILURES, 64 CO FAILURES, 50.0% FAILURE RATE

	# OF	HC		CO		NOX		MPG	
	VEH.	MEAN	S.D.	MEAN	S.D.	MEAN	S.D.	MEAN	S.D.
*VEHICLE MAKE									
AMER. MOTORS	10	0.738	1.56	8.37	17.36	-0.091	0.30	-0.530	1.19
BUICK	15	1.667	5.63	9.58	20.35	0.092	0.39	-0.227	0.64
CADILLAC	10	0.164	0.52	0.86	2.73	0.021	0.06	-0.053	0.17
CHEVROLET	67	1.288	6.79	13.32	38.64	0.060	0.75	-0.233	1.19
CHRYSLER	10	4.599	9.71	51.37	77.66	-0.385	0.61	-0.830	1.43
DATSUN	3	0.004	0.01	-1.47	2.54	0.235	0.41	0.086	0.15
DODGE	18	0.585	2.83	5.57	22.61	0.140	0.59	-0.275	0.78
FORD	68	0.775	3.15	4.21	15.18	0.092	0.84	-0.090	0.85
MERCURY	11	0.019	1.42	2.69	36.57	-0.118	0.62	0.236	1.17
OLDSMOBILE	16	-1.449	12.25	10.14	29.44	-0.065	0.31	-0.075	0.65
OPEL	3	0.406	0.70	6.18	10.70	-0.003	0.00	-0.061	0.10
PLYMOUTH	22	1.709	4.91	14.66	17.91	-0.076	0.43	-0.407	0.82
PONTIAC	20	1.964	5.33	4.87	26.73	-0.167	0.60	-0.244	0.95
TOYOTA	6	0.908	1.02	8.16	11.55	0.125	0.42	-0.871	1.41
VOLKSWAGON	20	0.711	1.11	3.40	16.84	0.293	0.74	-0.327	1.06
VOLVO	1	0.000	0.00	0.00	0.00	0.000	0.00	0.000	0.00
*MODEL YEAR									
1964	22	0.758	2.38	9.77	27.53	-0.040	0.35	-0.321	0.81
1965	30	1.620	7.86	8.85	38.51	-0.041	0.40	-0.225	1.32
1966	29	0.297	10.70	4.63	25.97	0.114	0.54	-0.360	1.07
1967	29	0.172	2.58	2.97	25.09	0.063	0.53	-0.016	0.98
1968	30	0.894	1.95	15.08	37.47	0.101	0.81	-0.187	1.09
1969	29	1.672	6.07	16.12	31.92	0.019	1.21	-0.514	0.93
1970	30	1.721	4.77	8.57	22.07	0.234	0.99	-0.069	0.98
1971	35	1.377	4.21	8.24	14.65	-0.022	0.51	-0.492	0.91
1972	33	1.150	5.48	13.37	43.94	-0.072	0.43	-0.157	1.02
1973	33	0.367	1.15	4.96	16.14	-0.026	0.18	0.040	0.37
*DISPLACEMENT									
LESS THAN 151	39	0.792	1.22	4.83	10.38	0.188	0.57	-0.419	1.03
151 - 250	47	0.178	2.24	2.59	17.10	0.076	0.33	-0.093	1.09
251 - 350	126	1.867	5.40	14.00	31.70	0.042	0.74	-0.307	0.98
MORE THAN 350	88	0.340	7.36	7.92	35.98	-0.076	0.70	-0.102	0.87
*INERTIA WEIGHT									
1800 - 2799	46	0.719	1.15	4.34	11.32	0.192	0.54	-0.338	1.13
2800 - 3799	127	0.546	3.70	7.42	21.60	0.058	0.68	-0.128	0.94
3800 - 4799	112	1.786	7.89	14.43	41.52	-0.062	0.72	-0.326	1.01
4800 - 5799	15	0.131	0.42	0.83	2.37	0.020	0.06	0.001	0.20
*POPULATIONS									
1964 - 1967	110	0.719	7.00	6.37	29.72	0.027	0.47	-0.225	1.07
1968 - 1973	190	1.185	4.27	10.90	29.45	0.035	0.75	-0.230	0.92
ALL VEHICLES	300	1.015	5.43	9.24	29.58	0.032	0.66	-0.228	0.98

PERCENT REDUCTIONS AND REDUCTIONS PER DOLLAR

1975 FEDERAL TEST PROCEDURE

1964-1967 VEHICLES: 37 HC FAILURES, 36 CO FAILURES, 50.0% FAILURE RATE
1968-1973 VEHICLES: 61 HC FAILURES, 64 CO FAILURES, 50.0% FAILURE RATE

	# OF	------PERCENT REDUCTIONS------				MILLIGRAMS/MILE/DOLLAR		
	VEH.	HC	CO	NOX	MPG	HC	CO	NOX
*VEHICLE MAKE								
AMER. MOTORS	10	10.06	8.13	-3.36	-3.53	87.1	988.2	-10.7
BUICK	15	16.66	6.46	3.92	-1.89	147.4	847.0	8.1
CADILLAC	10	2.37	0.68	0.76	-0.51	44.8	236.6	5.6
CHEVROLET	67	14.36	11.15	2.61	-1.68	124.0	1282.1	5.8
CHRYSLER	10	39.96	29.75	-18.25	-7.68	271.1	3027.7	-22.7
DATSUN	3	0.08	-3.57	8.47	0.37	0.5	-200.1	32.0
DODGE	18	8.04	5.45	4.73	-1.84	65.9	627.3	15.7
FORD	68	10.72	4.42	3.09	-0.61	94.4	512.2	11.2
MERCURY	11	0.24	2.71	-3.36	1.74	1.4	205.6	-9.0
OLDSMOBILE	16	-18.57	8.47	-2.74	-0.61	-167.8	1173.8	-7.5
OPEL	3	8.99	8.83	-0.13	-0.28	44.2	674.2	-0.3
PLYMOUTH	22	20.40	11.92	-3.37	-2.84	168.4	1444.8	-7.5
PONTIAC	20	21.42	4.12	-6.26	-1.96	168.9	418.9	-14.4
TOYOTA	6	20.47	11.21	4.95	-4.63	59.2	532.0	8.1
VOLKSWAGON	20	11.18	4.15	13.29	-1.53	92.7	443.4	38.2
VOLVO	1	0.00	0.00	0.00	0.00	0.0	0.0	0.0
*MODEL YEAR								
1964	22	7.56	6.66	-1.88	-2.27	68.9	888.0	-3.7
1965	30	13.67	5.36	-2.04	-1.60	181.3	985.0	-4.6
1966	29	2.67	3.29	5.26	-2.53	29.0	452.5	11.1
1967	29	1.75	2.16	2.00	-0.11	19.9	344.0	7.3
1968	30	12.40	13.29	3.57	-1.31	70.9	1195.9	8.0
1969	29	23.41	16.54	0.58	-3.65	139.0	1339.9	1.5
1970	30	24.67	9.92	6.94	-0.47	166.1	826.5	22.6
1971	35	21.36	9.97	-0.70	-3.26	137.0	819.8	-2.2
1972	33	19.03	14.45	-2.72	-1.05	165.1	1920.2	-10.3
1973	33	8.03	6.33	-1.30	0.27	51.8	699.4	-3.7
*DISPLACEMENT								
LESS THAN 151	39	13.61	6.10	8.32	-2.01	84.3	514.0	20.0
151 - 250	47	2.64	2.66	3.18	-0.55	29.7	433.4	12.8
251 - 350	126	20.82	11.82	1.71	-2.26	171.9	1228.6	3.9
MORE THAN 350	88	4.15	6.59	-2.50	-0.87	33.3	777.9	-7.4
*INERTIA WEIGHT								
1800 - 2799	46	12.42	5.57	8.15	-1.63	82.0	494.2	21.9
2800 - 3799	127	7.21	7.16	2.40	-0.86	60.6	823.5	6.5
3800 - 4799	112	18.83	11.19	-2.19	-2.69	152.5	1232.8	-5.3
4800 - 5799	15	1.89	0.65	0.74	0.01	37.0	233.6	5.7
*POPULATIONS								
1964 - 1967	110	6.68	4.45	1.28	-1.58	74.7	661.9	2.8
1968 - 1973	190	18.63	11.03	1.21	-1.57	121.5	1116.8	3.5
ALL VEHICLES	300	12.72	8.37	1.23	-1.57	104.5	951.4	3.3

EXHAUST EMISSIONS AFTER INSPECTION AND MAINTENANCE

1975 FEDERAL TEST PROCEDURE

1964-1967 VEHICLES: 42 HC FAILURES, 57 CO FAILURES, 60.0% FAILURE RATE
1968-1973 VEHICLES: 87 HC FAILURES, 85 CO FAILURES, 57.4% FAILURE RATE

	# OF	HC		CO		NOX		MPG	
	VEH.	MEAN	S.D.	MEAN	S.D.	MEAN	S.D.	MEAN	S.D.
*VEHICLE MAKE									
AMER. MOTORS	10	6.59	1.05	94.6	23.4	2.79	1.41	15.53	3.41
BUICK	15	8.34	5.88	138.7	45.4	2.25	1.21	12.23	1.45
CADILLAC	10	6.67	3.58	123.8	55.2	2.67	1.30	10.54	1.30
CHEVROLET	67	7.61	5.78	104.8	52.7	2.23	1.13	14.19	2.33
CHRYSLER	10	7.14	2.31	120.2	30.1	2.48	1.01	11.67	1.22
DATSUN	3	4.00	0.70	40.9	5.5	2.57	0.79	23.16	1.76
DODGE	18	6.60	4.37	94.3	41.8	2.83	1.01	15.28	1.92
FORD	68	6.48	2.54	91.0	35.4	2.83	1.45	14.89	3.13
MERCURY	11	7.82	5.19	96.7	85.8	3.61	2.58	13.32	1.90
OLDSMOBILE	16	9.25	11.44	109.6	38.8	2.42	1.13	12.32	1.39
OPEL	3	3.74	0.98	57.9	19.6	2.32	0.95	21.90	0.54
PLYMOUTH	22	6.68	2.96	108.4	43.6	2.25	0.95	14.71	2.28
PONTIAC	20	6.85	3.04	110.7	64.1	2.86	1.45	12.71	1.30
TOYOTA	6	3.53	0.65	64.6	42.9	2.39	1.19	19.70	2.96
VOLKSWAGON	20	5.65	2.09	77.0	21.6	1.92	0.71	21.86	2.30
VOLVO	1	3.29	0.00	30.9	0.0	4.82	0.00	21.66	0.00
*MODEL YEAR									
1964	22	8.88	2.88	132.3	49.0	2.22	1.60	14.53	3.37
1965	30	10.21	7.73	137.9	52.3	2.07	1.18	14.35	3.71
1966	29	11.01	8.84	135.7	54.0	2.05	0.90	14.59	3.41
1967	29	9.54	3.81	134.3	50.0	2.06	1.65	14.56	3.31
1968	30	6.28	2.18	97.0	33.1	2.66	1.19	14.53	2.72
1969	29	5.47	1.29	81.3	29.9	3.22	1.26	14.57	2.81
1970	30	5.28	1.22	77.9	30.3	3.12	1.19	14.67	3.21
1971	35	5.07	1.34	74.4	34.1	3.22	1.39	15.58	4.78
1972	33	4.73	1.52	76.7	32.0	2.68	1.04	15.12	3.69
1973	33	4.25	1.15	73.6	25.1	2.00	0.80	14.96	3.98
*DISPLACEMENT									
LESS THAN 151	39	5.02	1.87	73.1	32.0	2.08	0.95	21.36	2.58
151 - 250	47	6.61	3.90	94.6	46.8	2.32	1.32	17.16	2.37
251 - 350	126	7.03	3.03	102.9	42.7	2.40	1.08	13.91	1.37
MORE THAN 350	88	7.79	7.17	111.1	56.1	3.08	1.57	11.82	1.52
*INERTIA WEIGHT									
1800 - 2799	46	5.08	1.85	72.8	30.8	2.18	1.13	21.07	2.65
2800 - 3799	127	7.04	4.72	96.2	43.7	2.36	1.11	14.99	2.07
3800 - 4799	112	7.56	5.50	112.7	52.4	2.89	1.52	12.47	1.43
4800 - 5799	15	6.81	3.15	124.4	48.2	2.67	1.19	10.81	1.30
*POPULATIONS									
1964 - 1967	110	9.98	6.47	135.2	50.9	2.09	1.33	14.50	3.42
1968 - 1973	190	5.16	1.59	79.8	31.5	2.81	1.23	14.93	3.62
ALL VEHICLES	300	6.92	4.72	100.2	47.8	2.55	1.31	14.77	3.55

EXHAUST EMISSION REDUCTIONS AFTER INSPECTION AND MAINTENANCE

1975 FEDERAL TEST PROCEDURE

1964-1967 VEHICLES: 42 HC FAILURES, 57 CO FAILURES, 60.0% FAILURE RATE
1968-1973 VEHICLES. 87 HC FAILURES, 35 CO FAILURES, 57.4% FAILURE RATE

	# OF VEH.	HC		CO		NOX		MPG	
		MEAN	S.D.	MEAN	S.D.	MEAN	S.D.	MEAN	S.D.
*VEHICLE MAKE									
AMER. MOTORS	10	0.738	1.56	8.37	17.36	-0.091	0.30	-0.530	1.19
BUICK	15	1.667	5.63	9.53	20.35	0.092	0.39	-0.227	0.64
CADILLAC	10	0.227	0.53	4.05	10.14	0.027	0.07	-0.118	0.25
CHEVROLET	67	1.358	6.81	14.64	39.05	0.059	0.75	-0.259	1.21
CHRYSLER	10	4.367	9.86	52.47	76.93	-0.368	0.62	-0.861	1.41
DATSUN	3	0.213	0.36	0.18	4.67	0.200	0.44	0.257	0.26
DODGE	18	0.678	2.83	7.92	23.65	0.126	0.61	-0.342	0.78
FORD	68	0.754	3.17	4.15	16.60	0.148	0.88	-0.077	0.89
MERCURY	11	0.019	1.42	2.69	36.52	-0.118	0.62	0.236	1.17
OLDSMOBILE	16	-1.449	12.25	10.14	29.44	-0.065	0.31	-0.075	0.65
OPEL	3	0.775	0.67	12.05	10.45	-0.131	0.22	-0.365	0.48
PLYMOUTH	22	1.702	4.92	14.59	18.51	0.004	0.64	-0.377	0.89
PONTIAC	20	2.315	5.39	7.59	27.57	-0.189	0.60	-0.255	0.96
TOYOTA	6	0.908	1.02	8.16	11.55	0.125	0.42	-0.871	1.41
VOLKSWAGON	20	0.713	1.22	4.94	14.32	0.286	0.81	-0.497	1.09
VOLVO	1	0.000	0.00	0.00	0.00	0.000	0.00	0.000	0.00
*MODEL YEAR									
1964	22	1.153	2.64	14.39	28.38	-0.080	0.37	-0.376	0.82
1965	30	1.709	7.88	10.55	39.80	-0.047	0.40	-0.250	1.34
1966	29	0.104	10.72	4.88	26.24	0.115	0.54	-0.377	1.08
1967	29	0.256	2.65	3.10	25.55	0.096	0.55	-0.018	0.98
1968	30	0.925	1.94	16.47	37.83	0.174	0.94	-0.242	1.17
1969	29	1.672	6.07	16.12	31.92	0.019	1.21	-0.514	0.93
1970	30	1.698	4.80	8.44	22.37	0.248	0.99	-0.063	0.99
1971	35	1.377	4.21	3.24	14.65	-0.022	0.51	-0.492	0.91
1972	33	1.308	5.46	15.82	43.56	-0.035	0.54	-0.220	1.09
1973	33	0.321	1.18	4.77	16.21	-0.007	0.22	0.033	0.41
*DISPLACEMENT									
LESS THAN 151	39	0.804	1.30	6.09	12.39	0.170	0.62	-0.501	1.06
151 - 250	47	0.112	2.28	2.69	17.70	0.086	0.35	-0.112	1.12
251 - 350	126	1.939	5.39	14.95	32.02	0.064	0.77	-0.326	1.00
MORE THAN 350	88	0.401	7.39	9.08	36.17	-0.055	0.73	-0.100	0.89
*INERTIA WEIGHT									
1800 - 2799	46	0.714	1.24	5.08	13.32	0.179	0.58	-0.388	1.16
2800 - 3799	127	0.526	3.71	7.46	21.77	0.078	0.70	-0.133	0.96
3800 - 4799	112	1.923	7.90	16.36	41.62	-0.041	0.75	-0.356	1.02
4800 - 5799	15	0.082	0.59	2.25	9.02	0.029	0.06	-0.008	0.30
*POPULATIONS									
1964 - 1967	110	0.791	7.05	7.86	30.66	0.027	0.48	-0.248	1.08
1968 - 1973	190	1.206	4.27	11.49	29.56	0.058	0.79	-0.250	0.95
ALL VEHICLES	300	1.054	5.45	10.16	29.97	0.047	0.69	-0.249	1.00

AUTOMOTIVE TESTING LABORATORIES, INC.
19900 E. COLFAX, AURORA, COLO. 80011

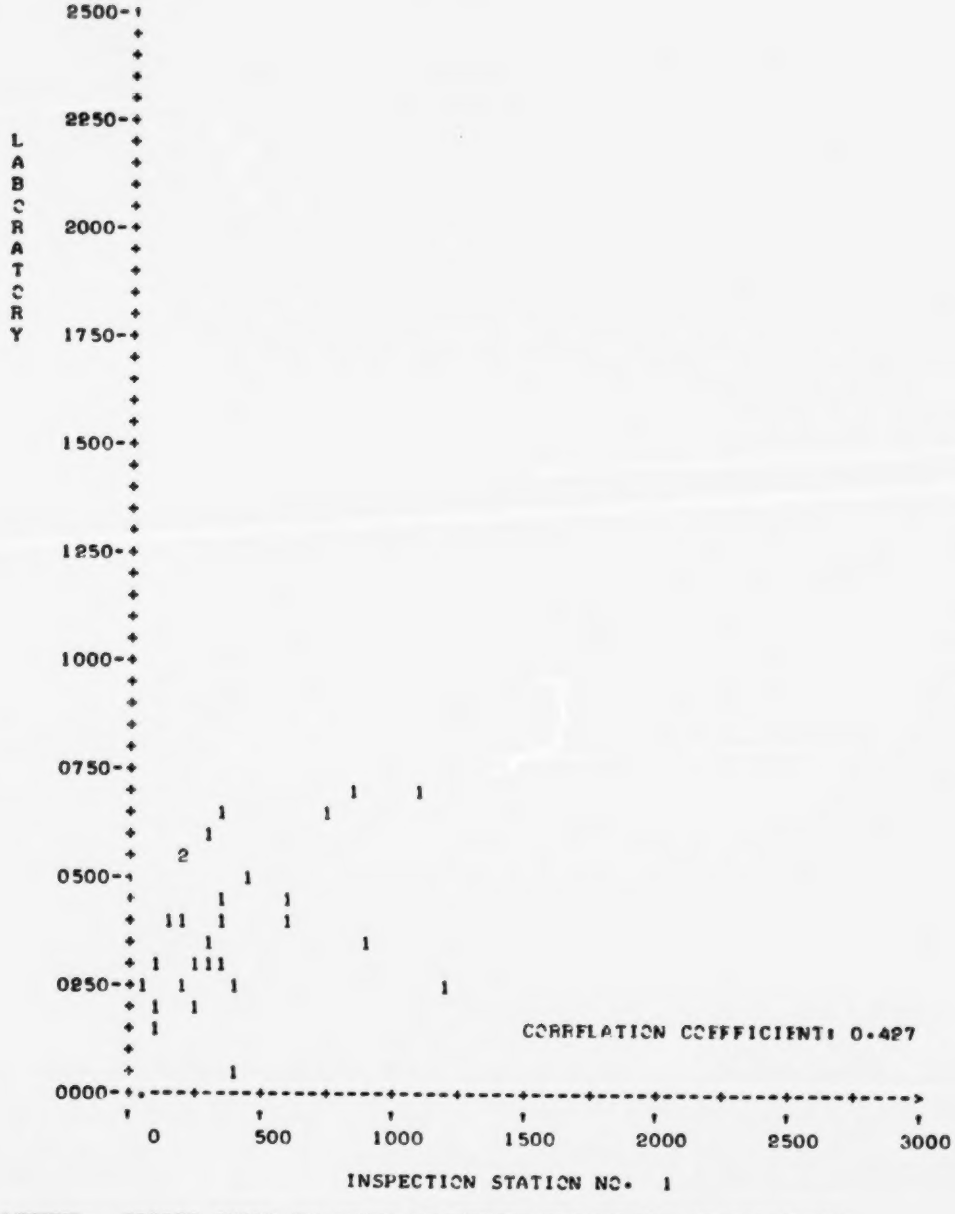
PERCENT REDUCTIONS AND REDUCTIONS PER DOLLAR

1975 FEDERAL TEST PROCEDURE

1964-1967 VEHICLES: 42 HC FAILURES, 57 CO FAILURES, 60.0% FAILURE RATE
1968-1973 VEHICLES: 87 HC FAILURES, 85 CO FAILURES, 57.4% FAILURE RATE

	# OF VEH.	------PERCENT REDUCTIONS------				MILLIGRAMS/MILE/DOLLAR		
		HC	CO	NOX	MPG	HC	CO	NOX
*VEHICLE MAKE								
AMER. MOTORS	10	10.06	8.13	-3.36	-3.53	87.1	988.2	-10.7
BUICK	15	16.66	6.46	3.92	-1.89	147.4	847.0	8.1
CADILLAC	10	3.29	3.17	1.02	-1.13	51.5	920.2	6.2
CHEVROLET	67	15.13	12.26	2.56	-1.86	125.1	1348.8	5.4
CHRYSLER	10	37.94	30.39	-17.47	-7.97	248.6	2986.9	-21.0
DATSUN	3	5.06	0.43	7.21	1.10	18.5	15.4	17.4
DODGE	18	9.31	7.75	4.26	-2.29	73.4	857.3	13.6
FORD	68	10.42	4.36	4.97	-0.52	84.6	465.2	16.6
MERCURY	11	0.24	2.71	-3.36	1.74	1.4	205.6	-9.0
OLDSMOBILE	16	-18.57	8.47	-2.74	-0.61	-167.8	1173.8	-7.5
OPEL	3	17.17	17.22	-5.96	-1.69	70.4	1095.4	-11.9
PLYMOUTH	22	20.31	11.87	0.16	-2.63	160.2	1373.4	0.3
PONTIAC	20	25.25	6.41	-7.06	-2.05	184.8	605.5	-15.1
TOYOTA	6	20.47	11.21	4.95	-4.63	59.2	532.0	8.1
VOLKSWAGON	20	11.21	6.03	12.96	-2.33	88.8	615.6	35.6
VOLVO	1	0.00	0.00	0.00	0.00	0.0	0.0	0.0
*MODEL YEAR								
1964	22	11.50	9.81	-3.77	-2.66	94.3	1176.6	-6.6
1965	30	14.33	7.11	-2.31	-1.77	183.6	1134.4	-5.0
1966	29	0.93	3.47	5.30	-2.65	9.4	440.6	10.4
1967	29	2.61	2.25	4.45	-0.12	28.0	339.4	10.5
1968	30	12.84	14.52	6.15	-1.70	69.1	1230.3	13.0
1969	29	23.41	16.54	0.58	-3.65	139.0	1339.9	1.5
1970	30	24.34	9.78	7.37	-0.43	158.5	788.1	23.2
1971	35	21.36	9.97	-0.70	-3.26	137.0	819.8	-2.2
1972	33	21.65	17.09	-1.31	-1.47	165.2	1997.8	-4.4
1973	33	7.01	6.09	-0.37	0.22	43.0	639.6	-1.0
*DISPLACEMENT								
LESS THAN 151	39	13.81	7.68	7.54	-2.40	78.5	595.1	16.6
151 - 250	47	1.66	2.77	3.59	-0.66	16.4	396.6	12.7
251 - 350	126	21.63	12.69	2.60	-2.40	173.2	1335.6	5.7
MORE THAN 350	88	4.89	7.56	-1.80	-0.85	37.6	853.5	-5.1
*INERTIA WEIGHT								
1800 - 2799	46	12.33	6.53	7.61	-1.88	74.9	533.1	18.8
2800 - 3799	127	6.95	7.20	3.19	-0.89	56.3	799.3	8.3
3800 - 4799	112	20.27	12.68	-1.43	-2.94	156.1	1328.6	-3.3
4800 - 5799	15	1.19	1.77	1.06	-0.08	19.7	539.3	6.9
*POPULATIONS								
1964 - 1967	110	7.35	5.49	1.26	-1.74	76.8	762.3	2.6
1968 - 1973	190	18.96	12.58	2.03	-1.70	118.7	1130.2	5.7
ALL VEHICLES	300	13.21	9.21	1.80	-1.71	103.2	994.1	4.6

HYDROCARBONS AT IDLE



LEGEND: DIGITS SHOWN ON GRAPH REPRESENT THE NUMBER OF COINCIDENT DATA POINTS. IF MORE THAN NINE ARE COINCIDENT, AN 'X' IS PRINTED.

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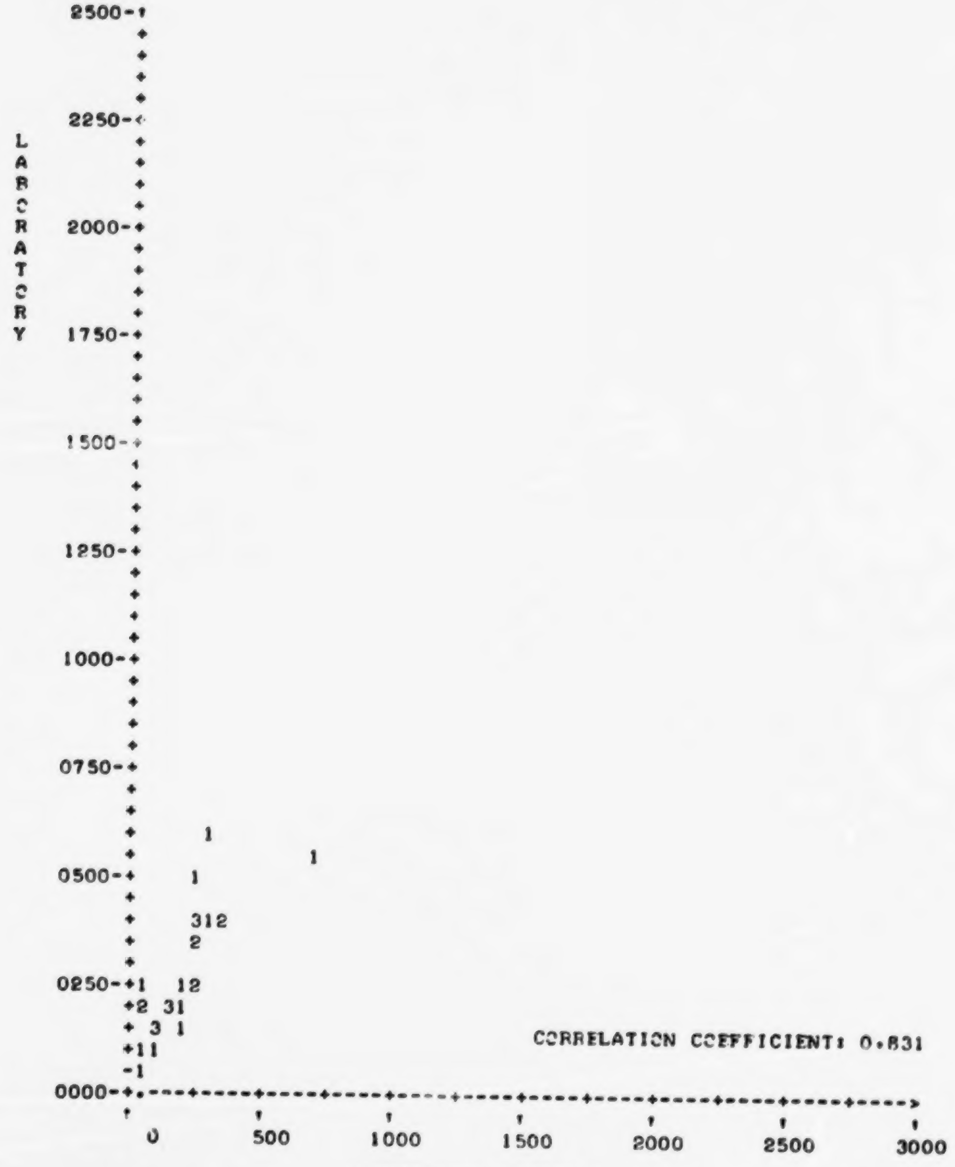
HYDROCARBONS AT 2500 RPM



CORRELATION COEFFICIENT: 0.831

LEGEND: DIGITS SHOWN ON GRAPH REPRESENT THE NUMBER OF COINCIDENT DATA POINTS. IF MORE THAN NINE ARE COINCIDENT, AN 'X' IS PRINTED.

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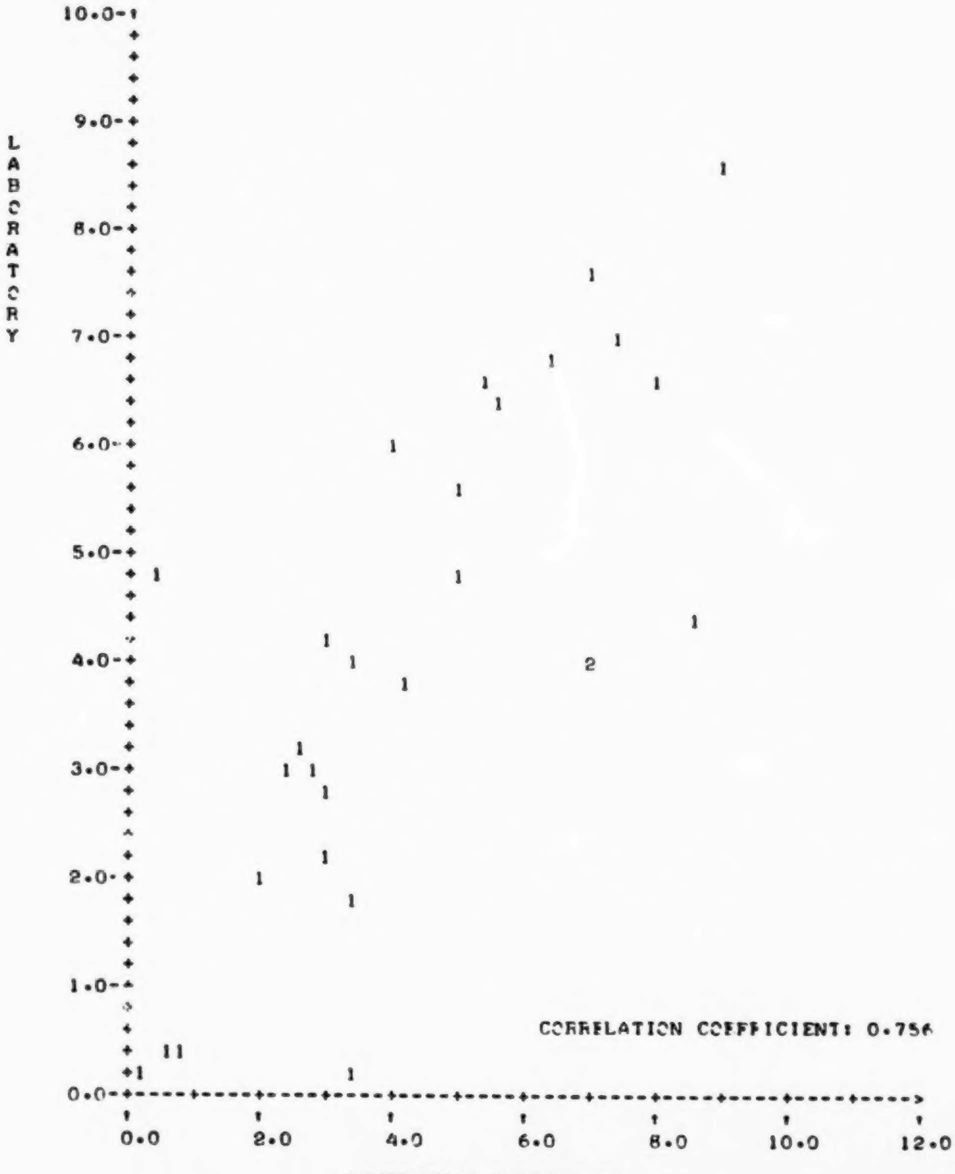
CARBON MONOXIDE AT IDLE



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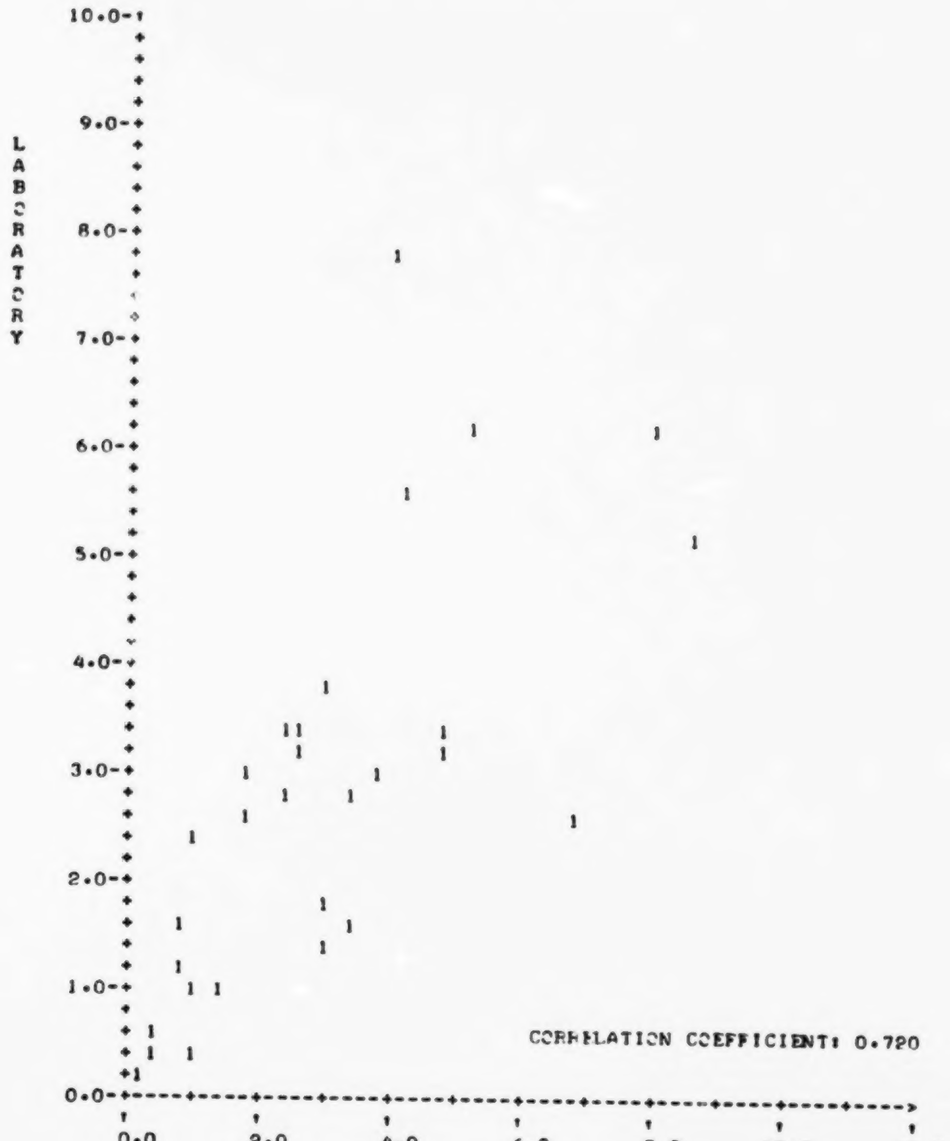
CARBON MONOXIDE AT 2500 RPM



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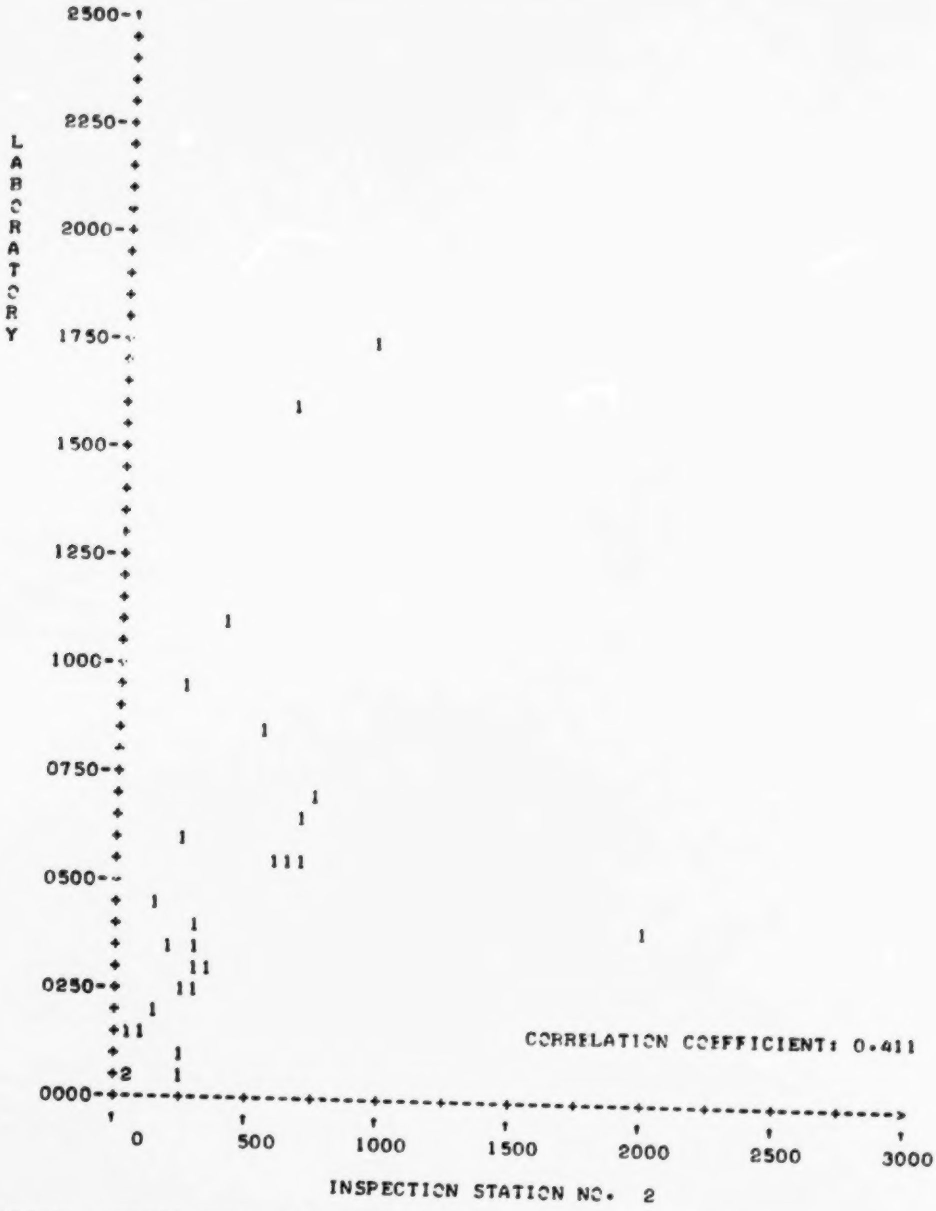
HYDROCARBONS AT IDLE



LEGEND: DIGITS SHOWN ON GRAPH REPRESENT THE NUMBER OF COINCIDENT DATA POINTS. IF MORE THAN NINE ARE COINCIDENT, AN 'X' IS PRINTED.

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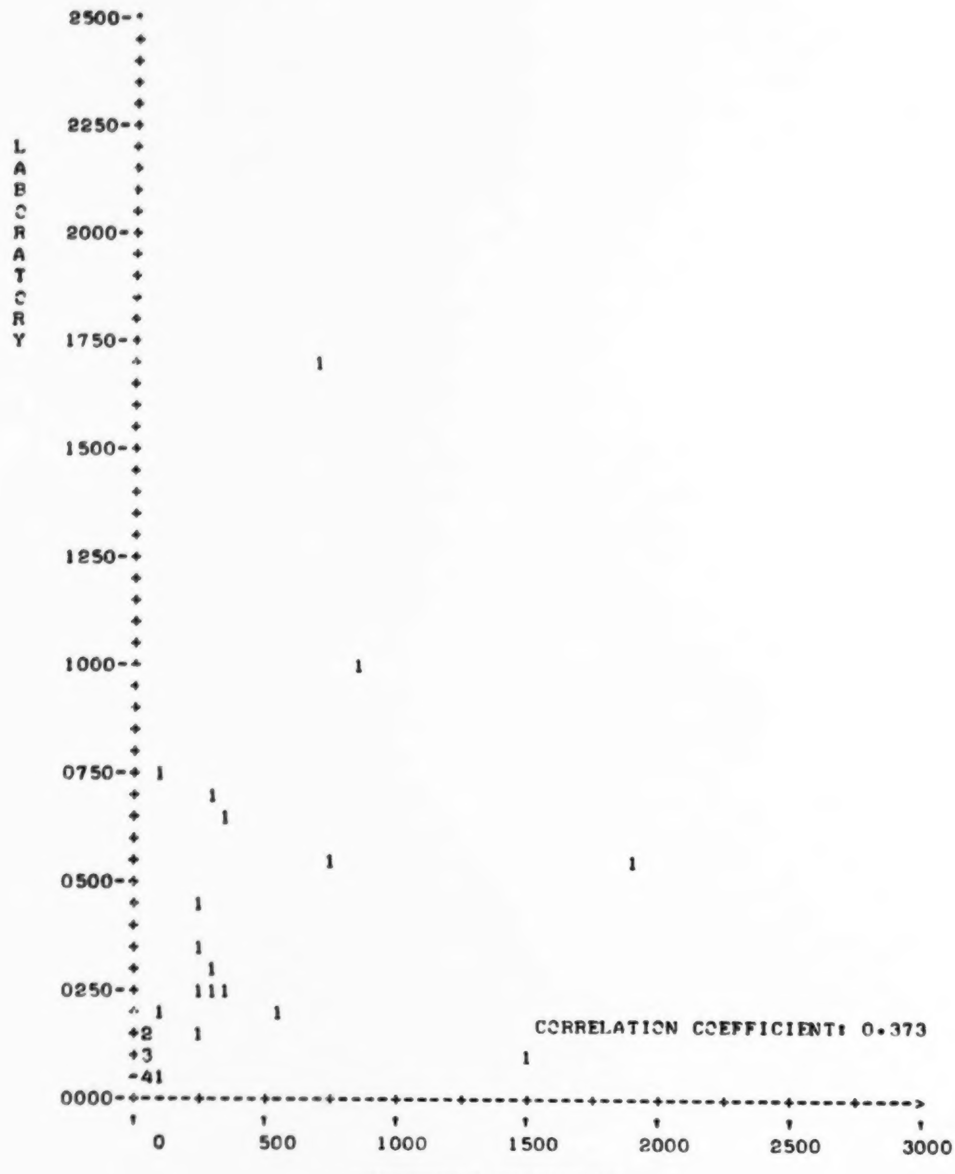
19900 E. COLFAX, AURORA, COLORADO 80011

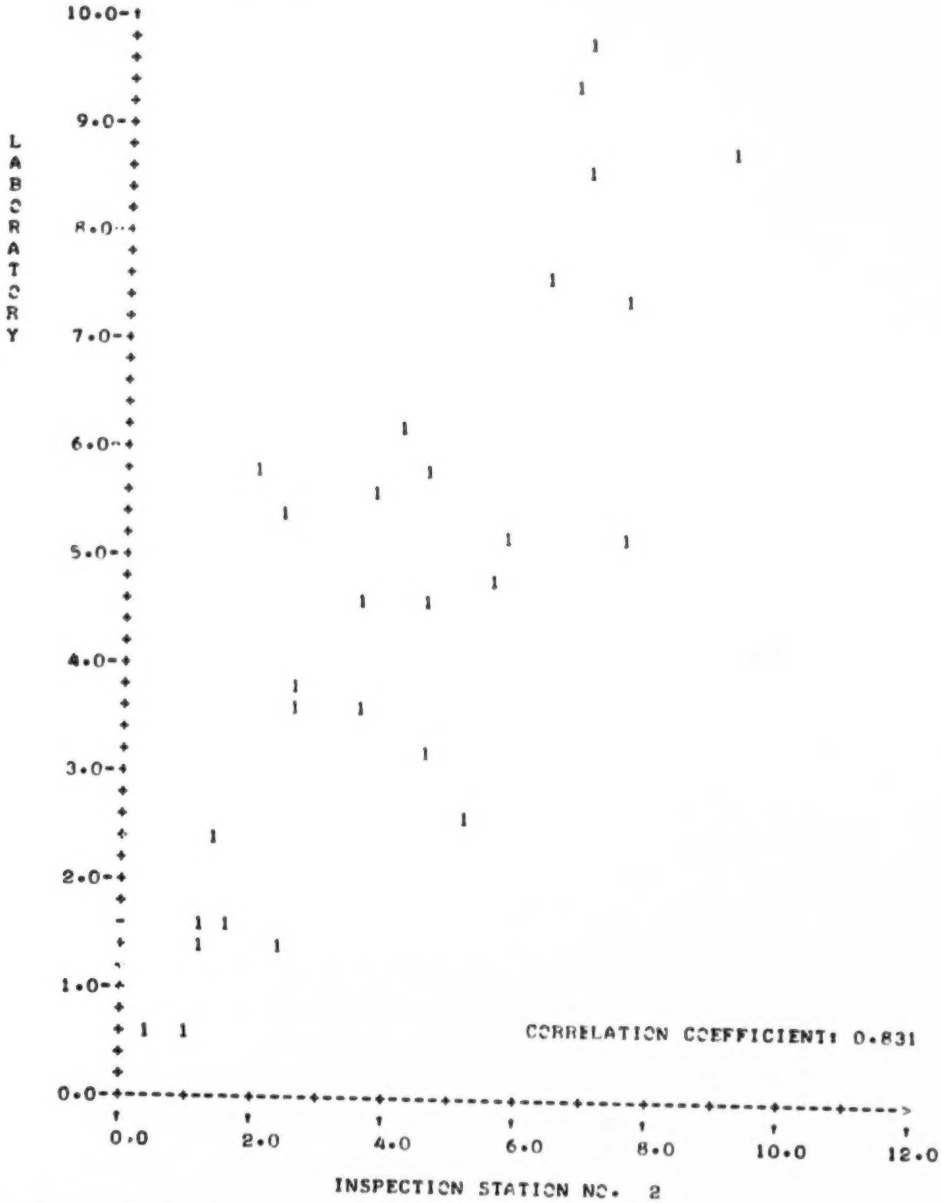
HYDROCARBONS AT 2500 RPM



LEGEND: DIGITS SHOWN ON GRAPH REPRESENT THE NUMBER OF COINCIDENT DATA POINTS. IF MORE THAN NINE ARE COINCIDENT, AN 'X' IS PRINTED.

AUTOMOTIVE TESTING LABORATORIES, INC.
19900 E. COLFAX, AURORA, COLORADO 80011

CARBON MONOXIDE AT IDLE



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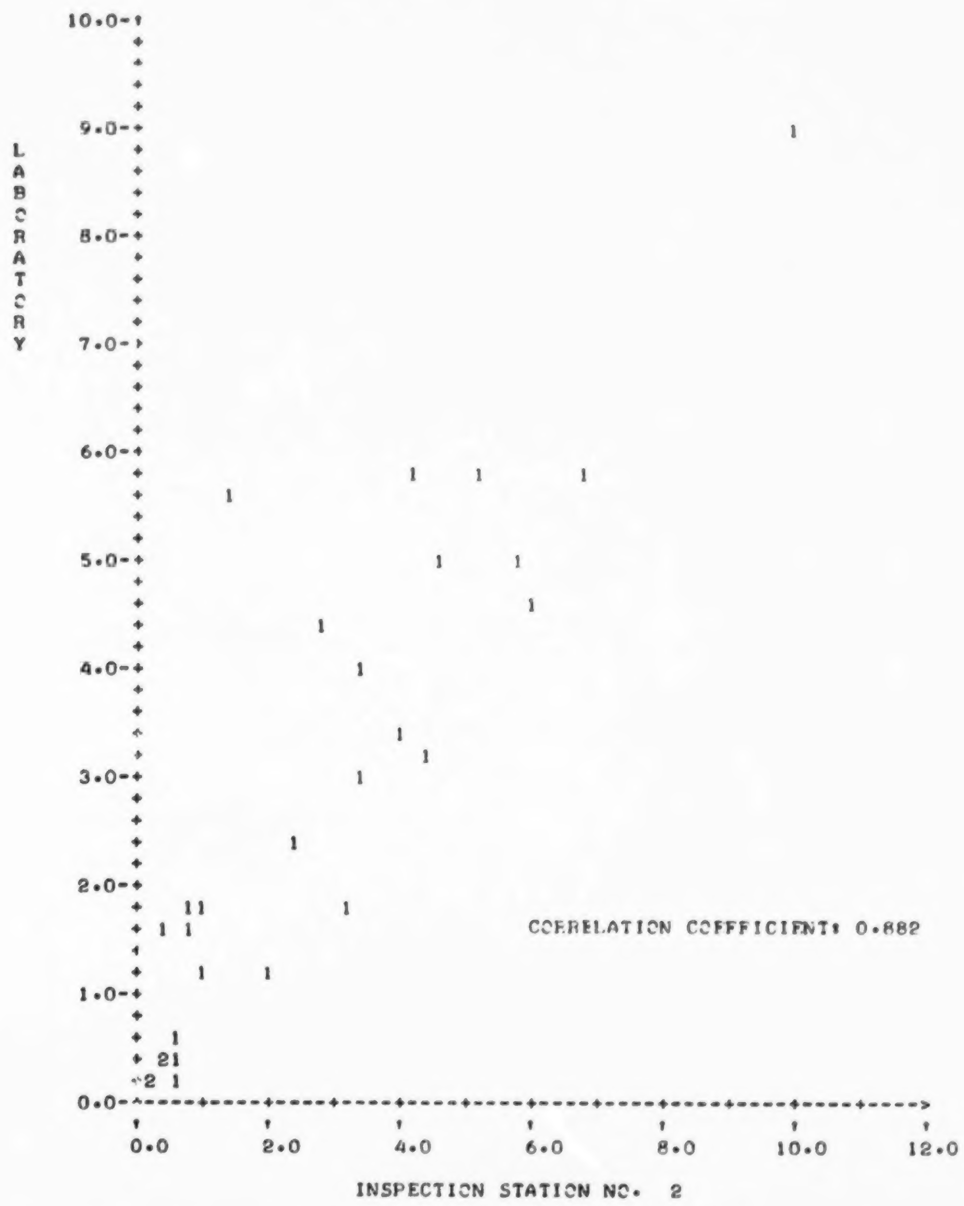
CARBON MONOXIDE AT 2500 RPM



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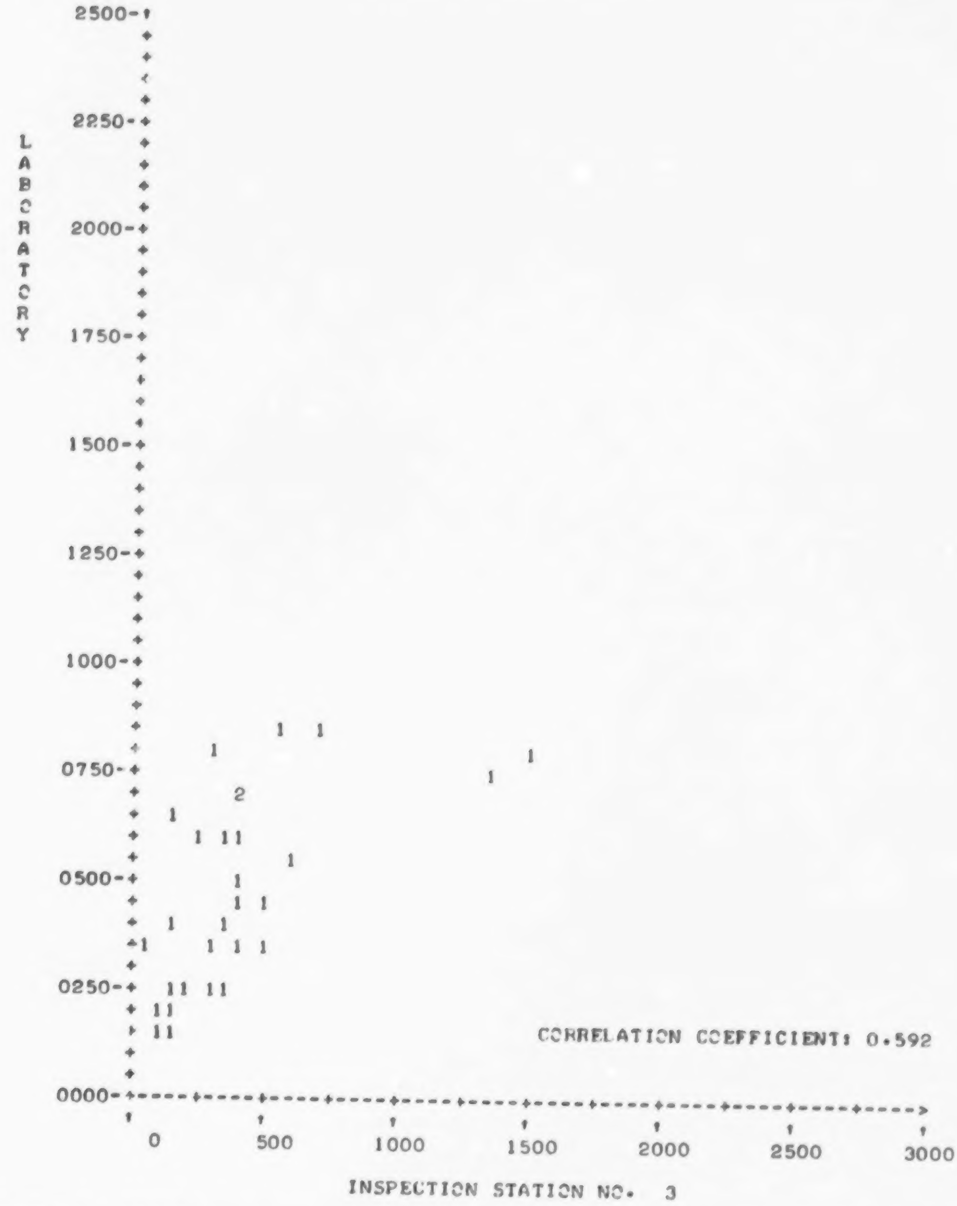

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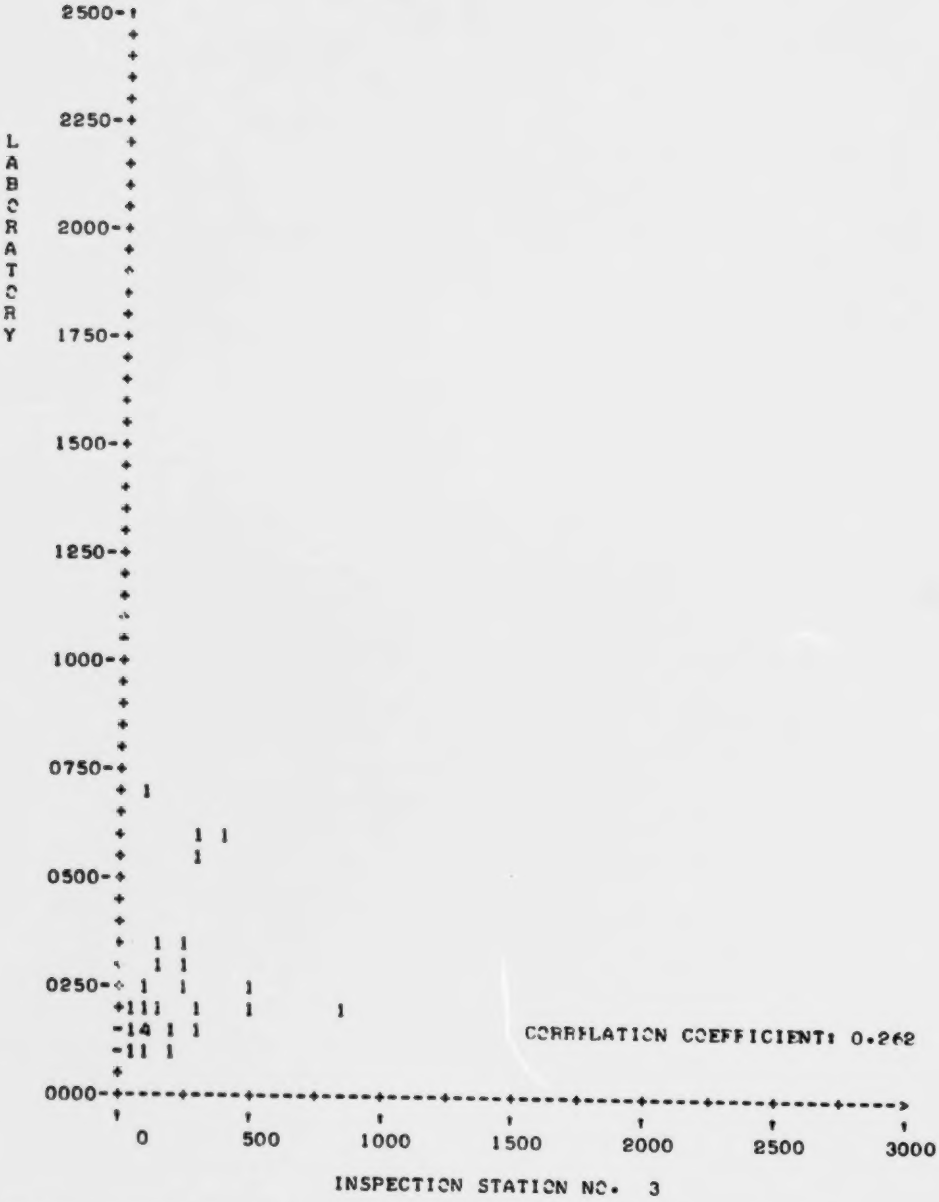

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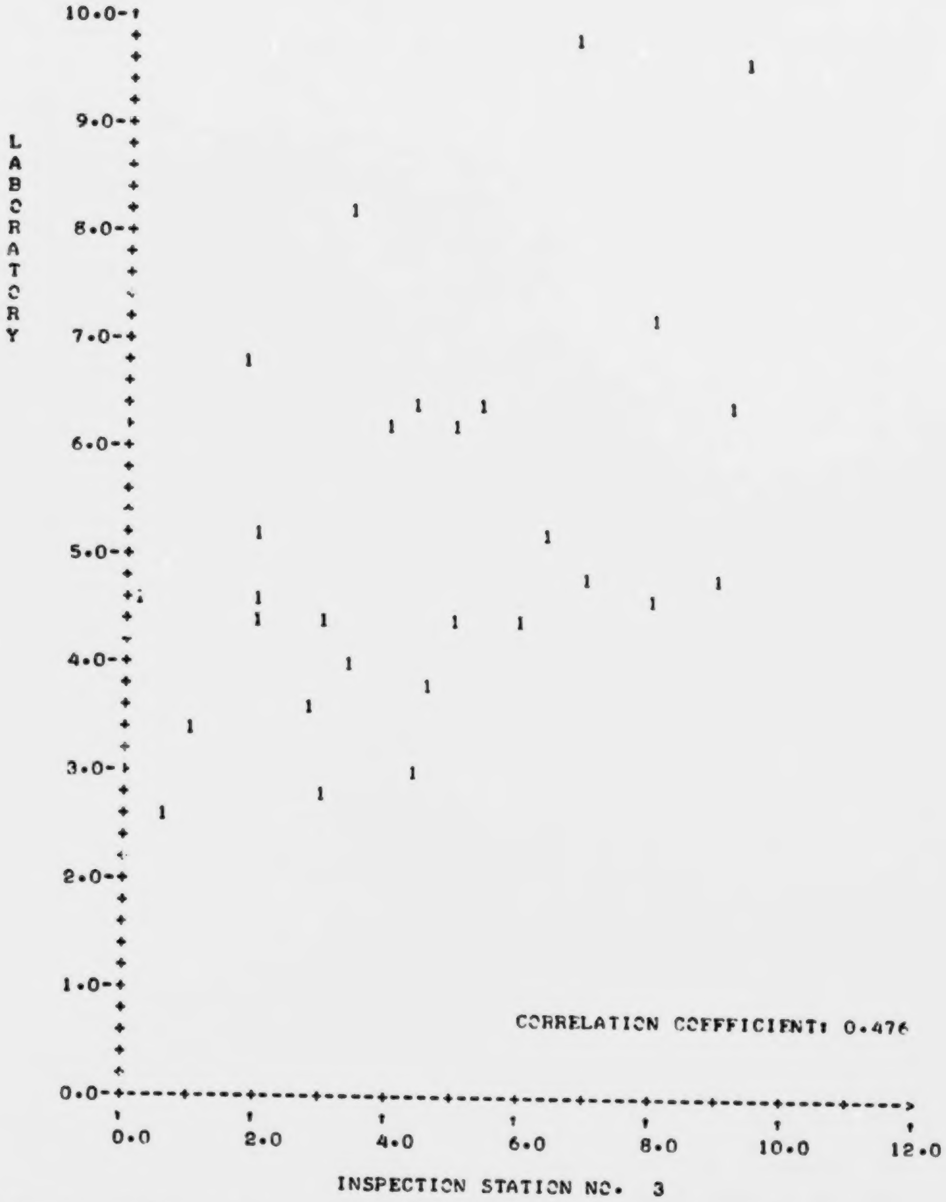

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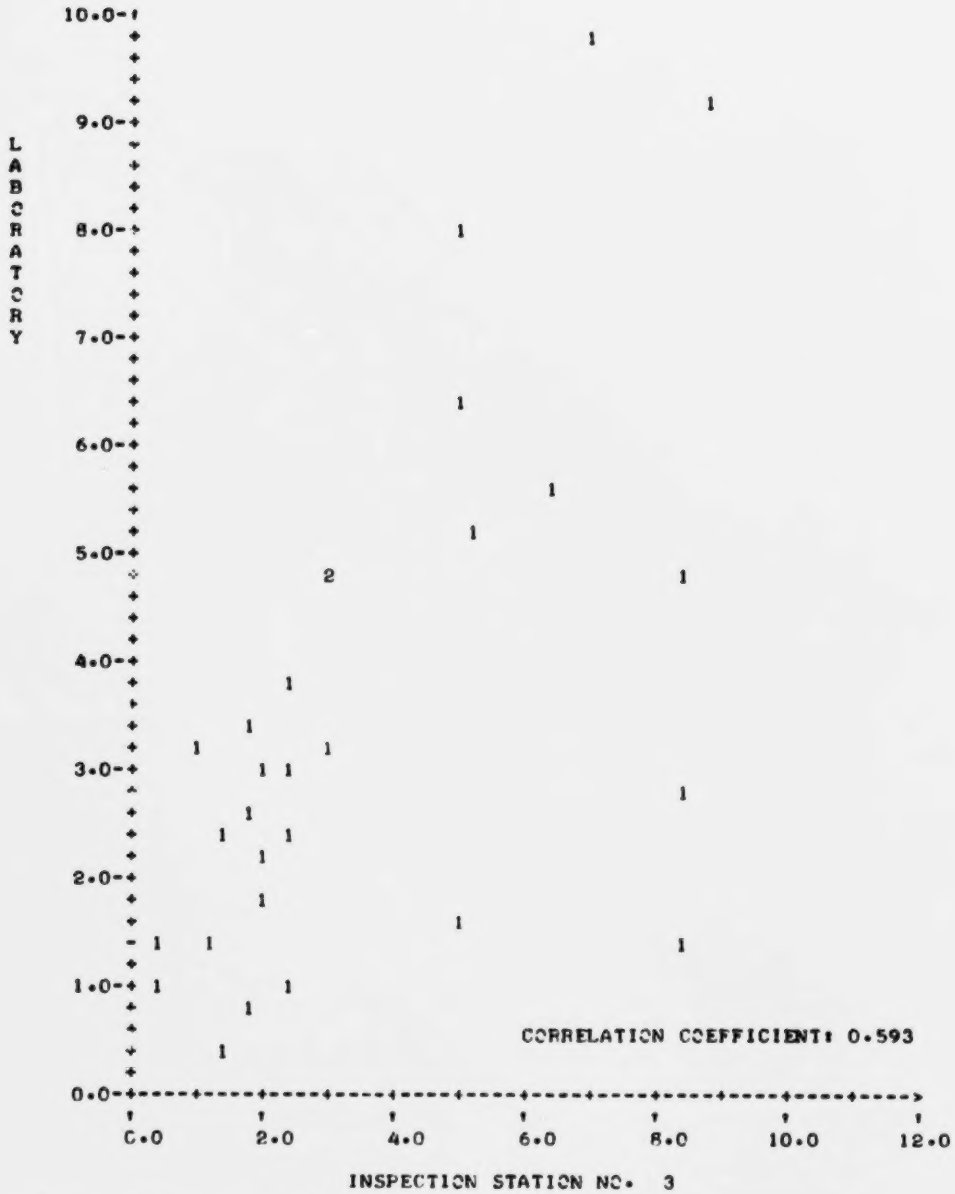

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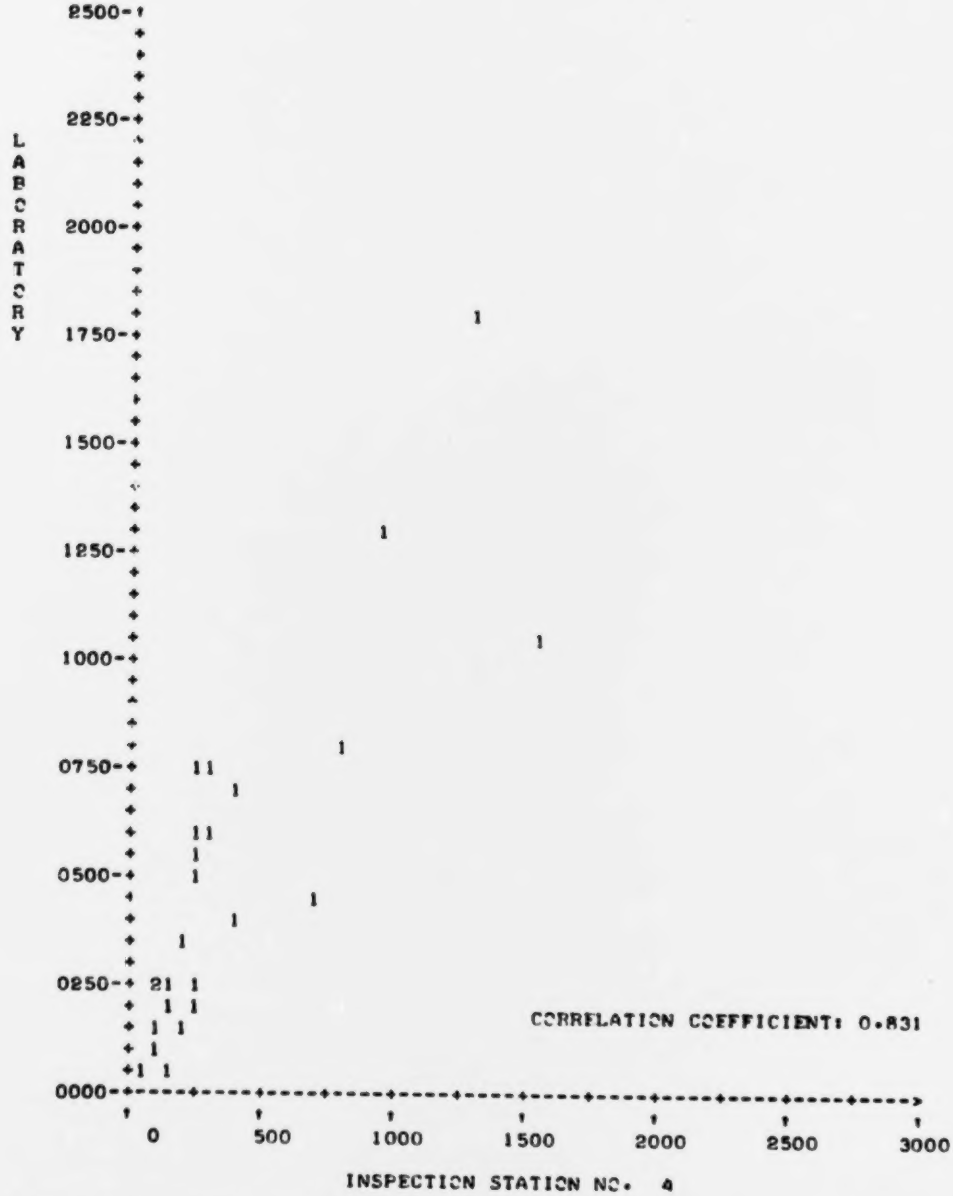

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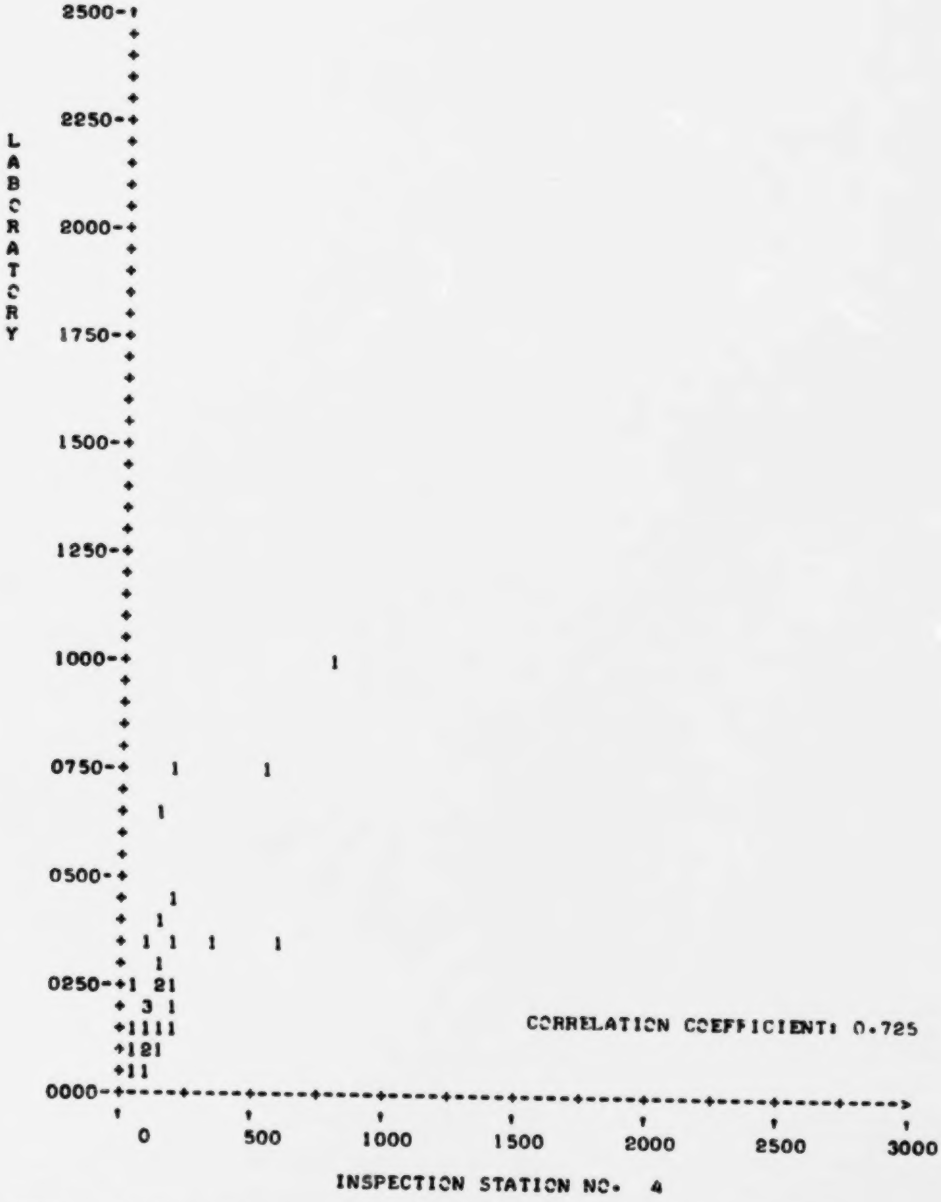

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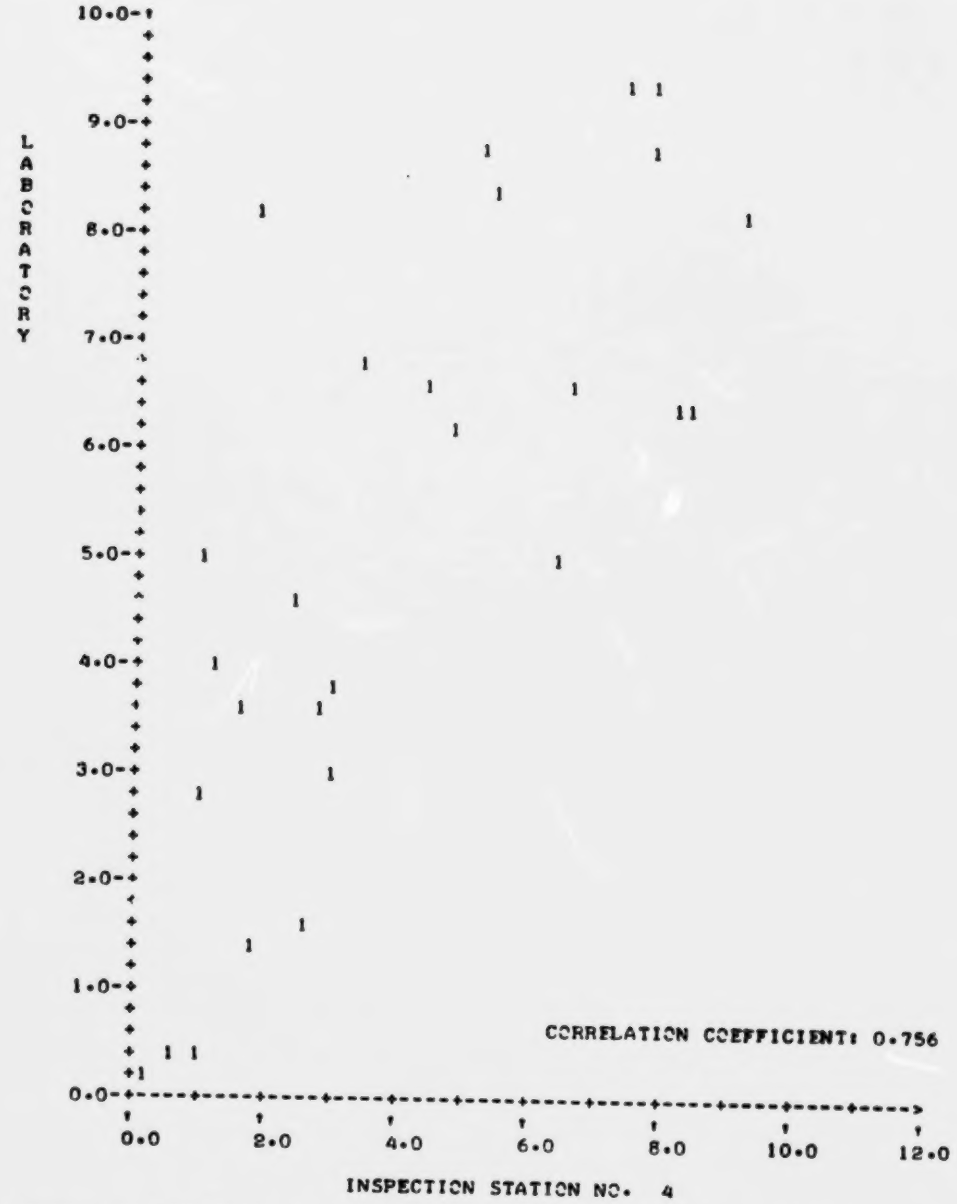

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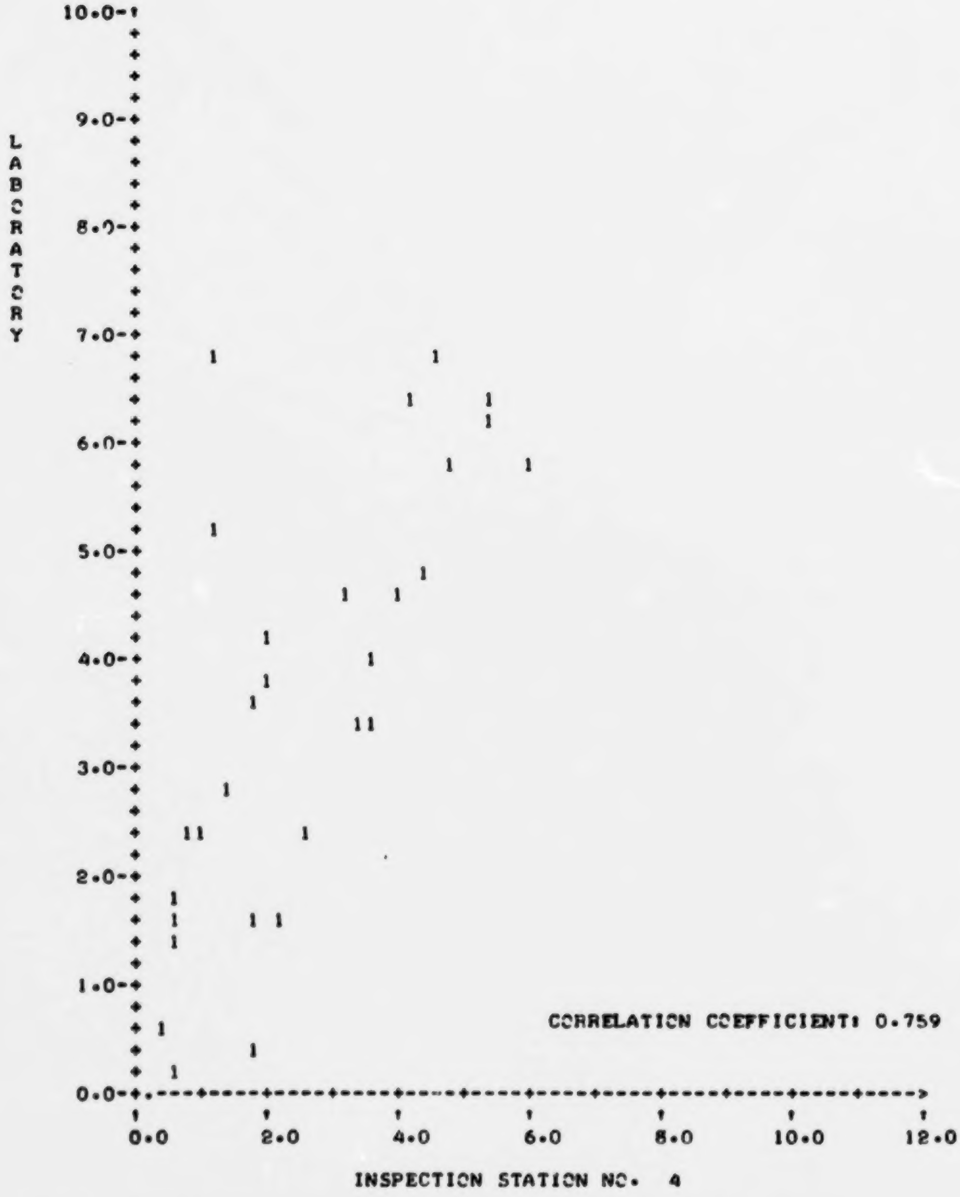

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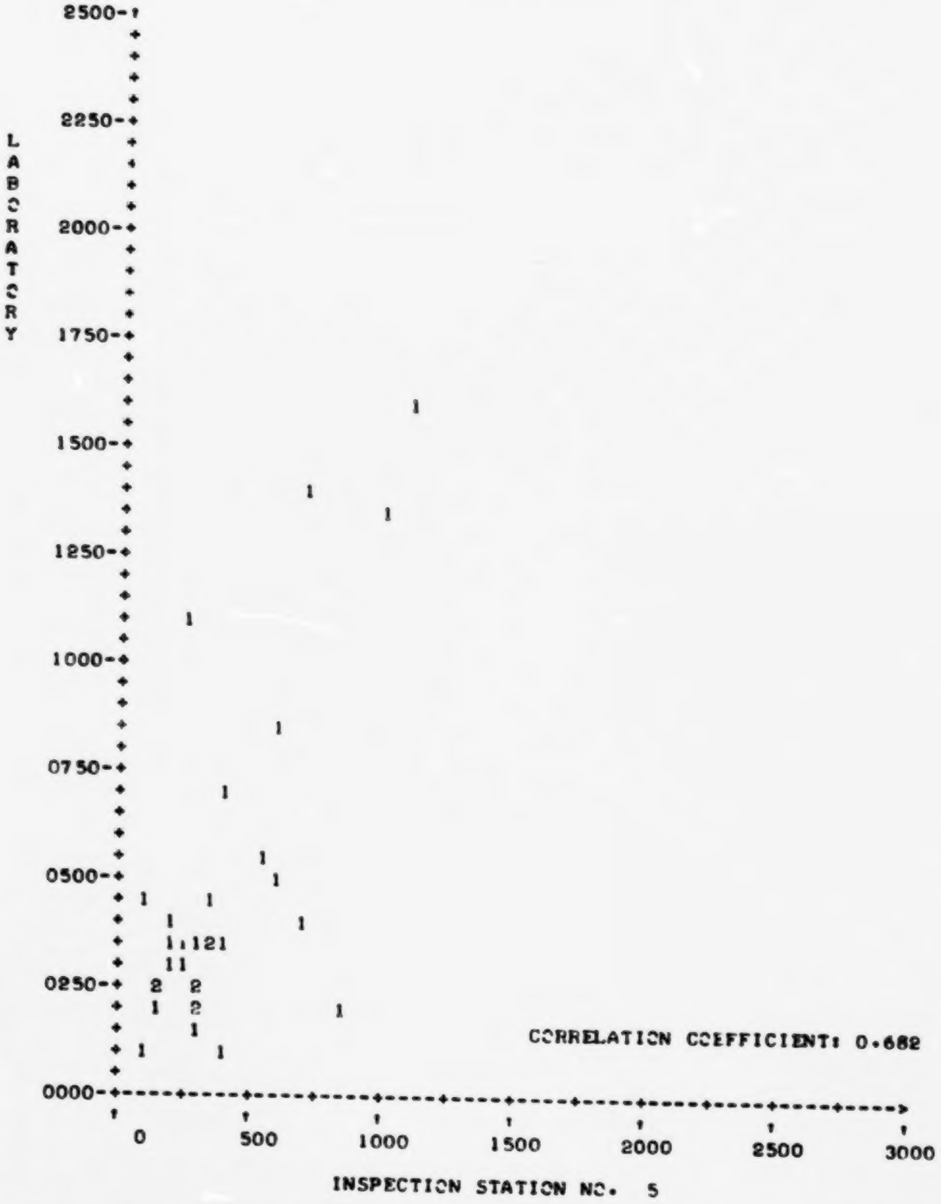

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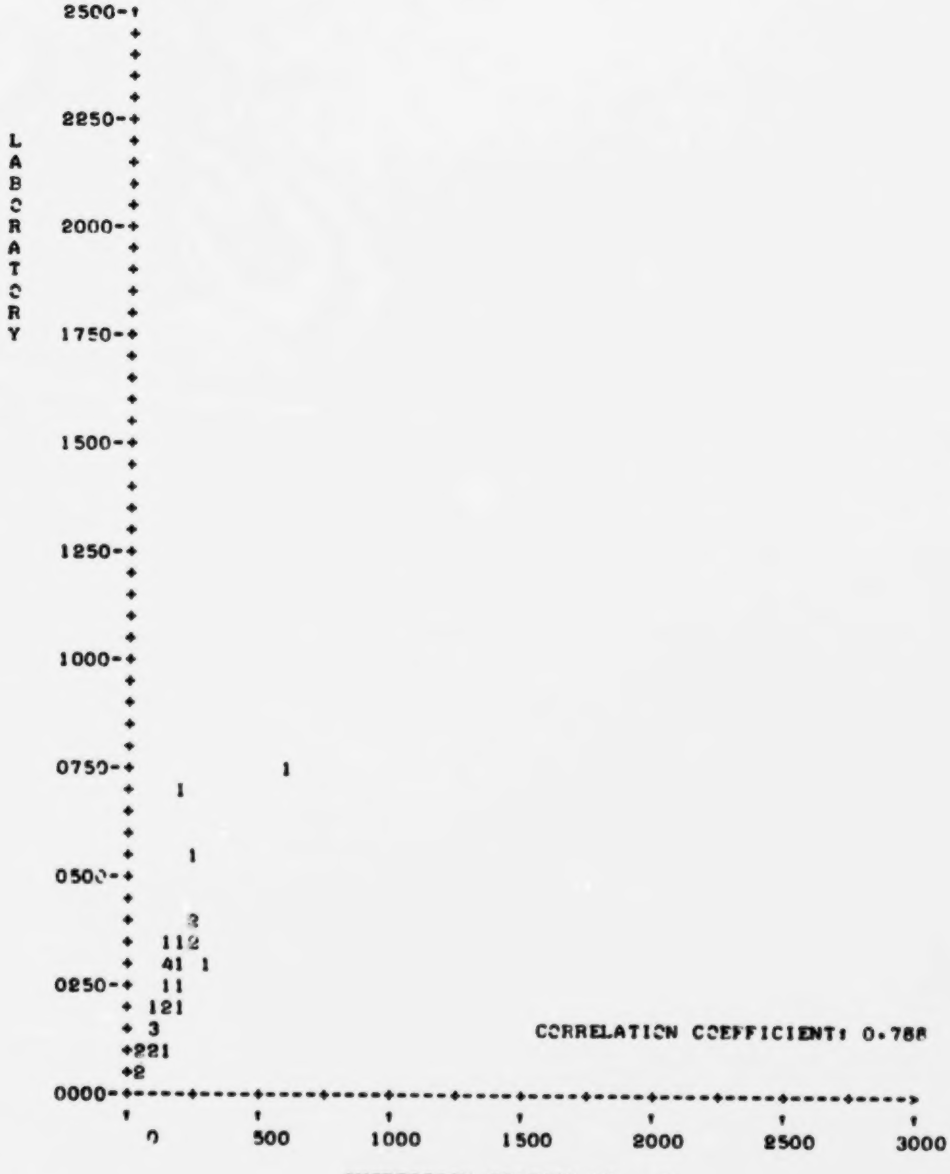

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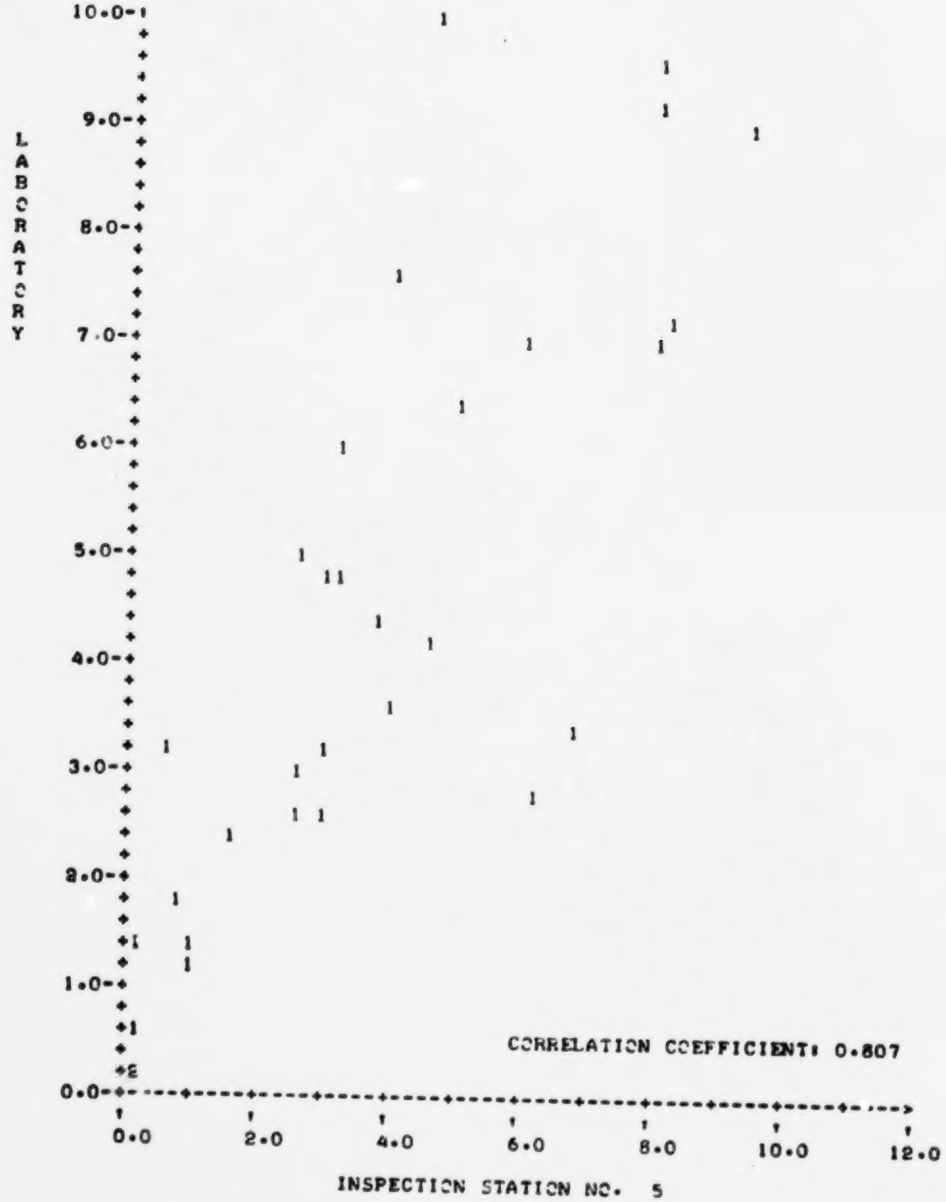

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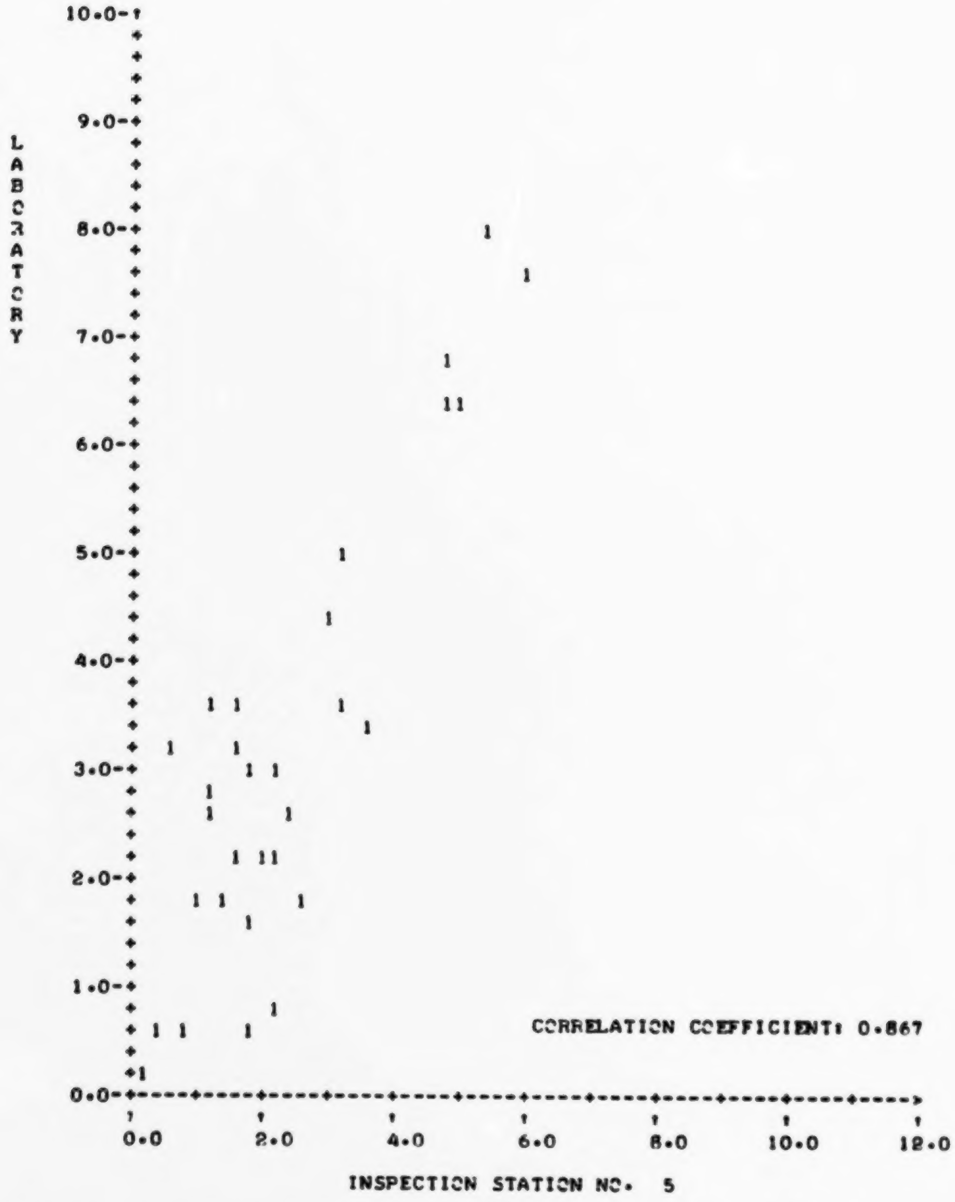

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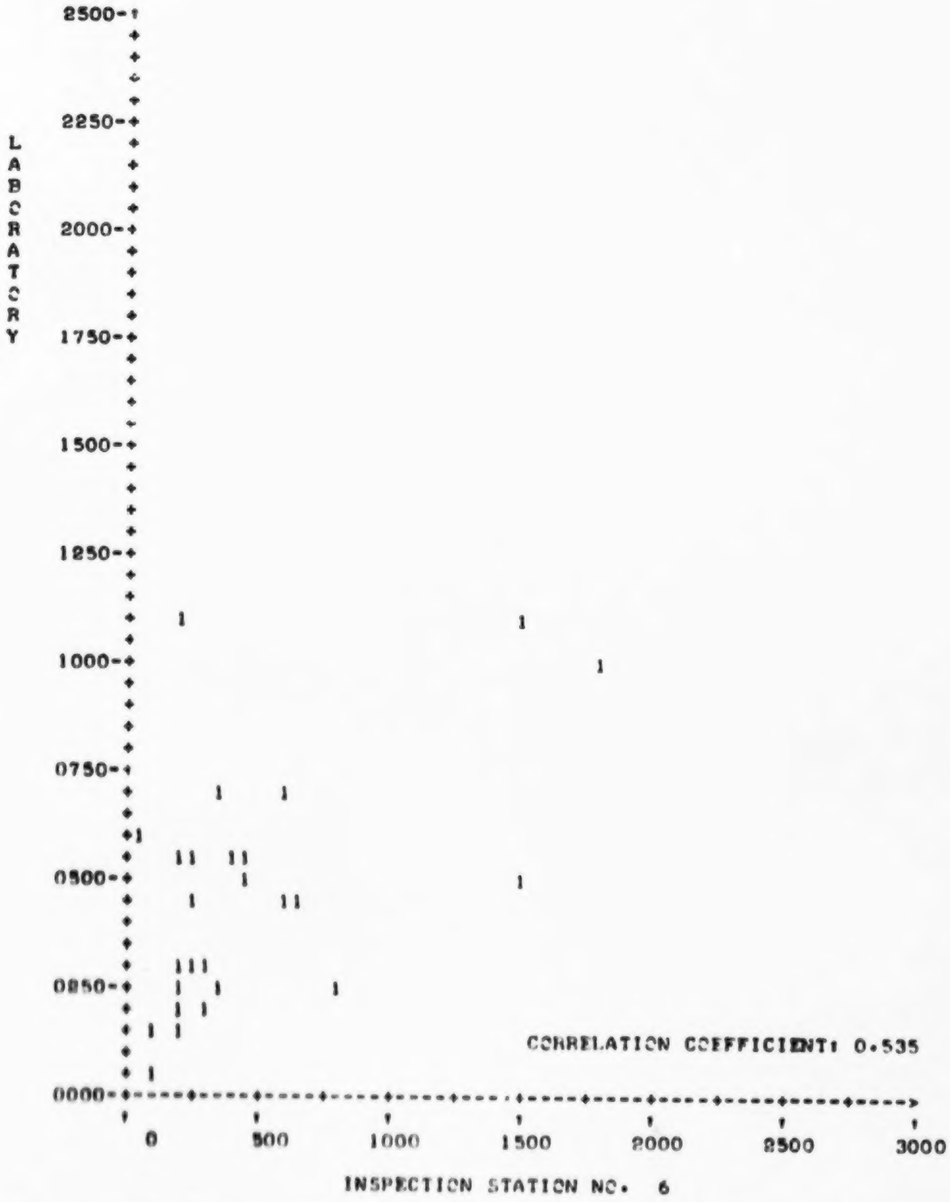

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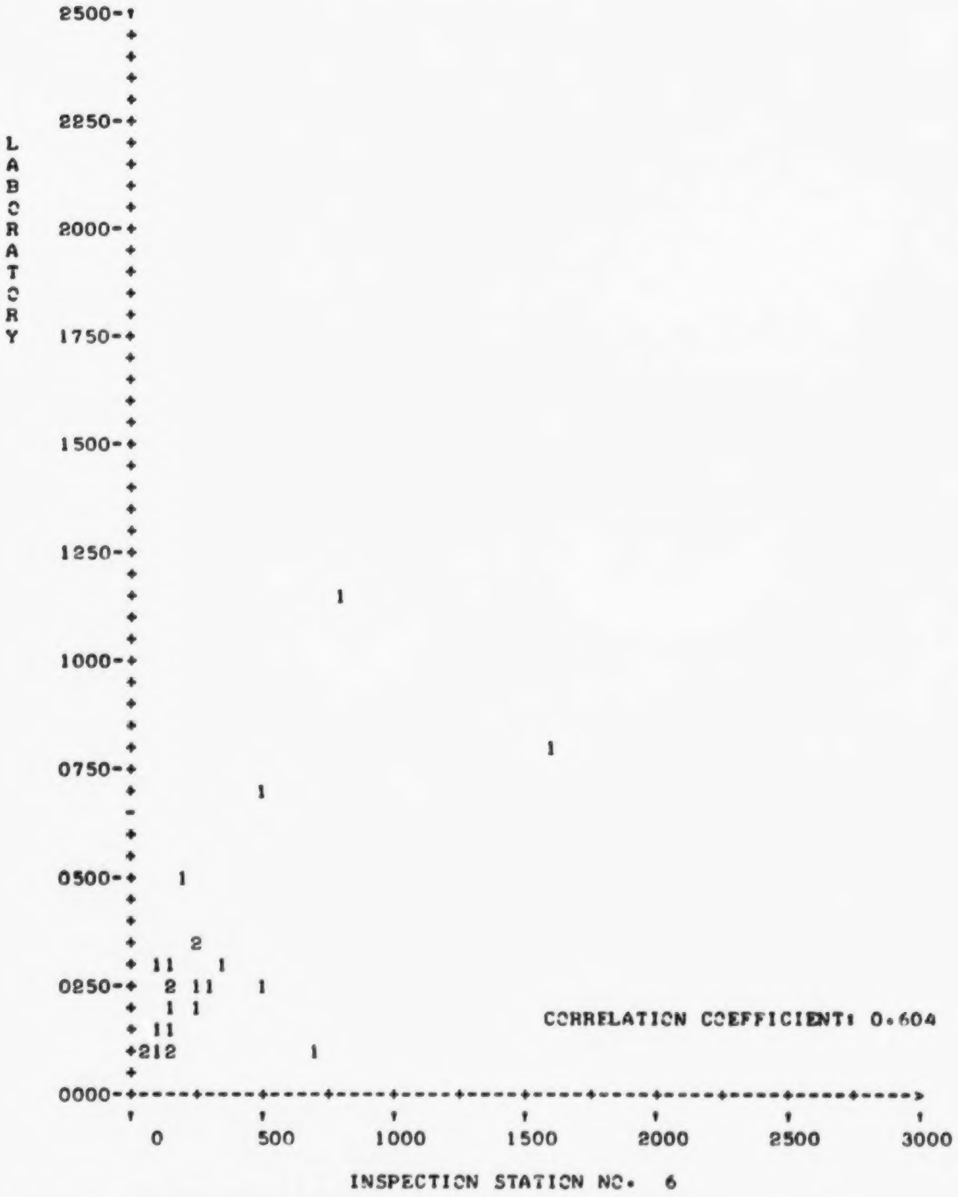

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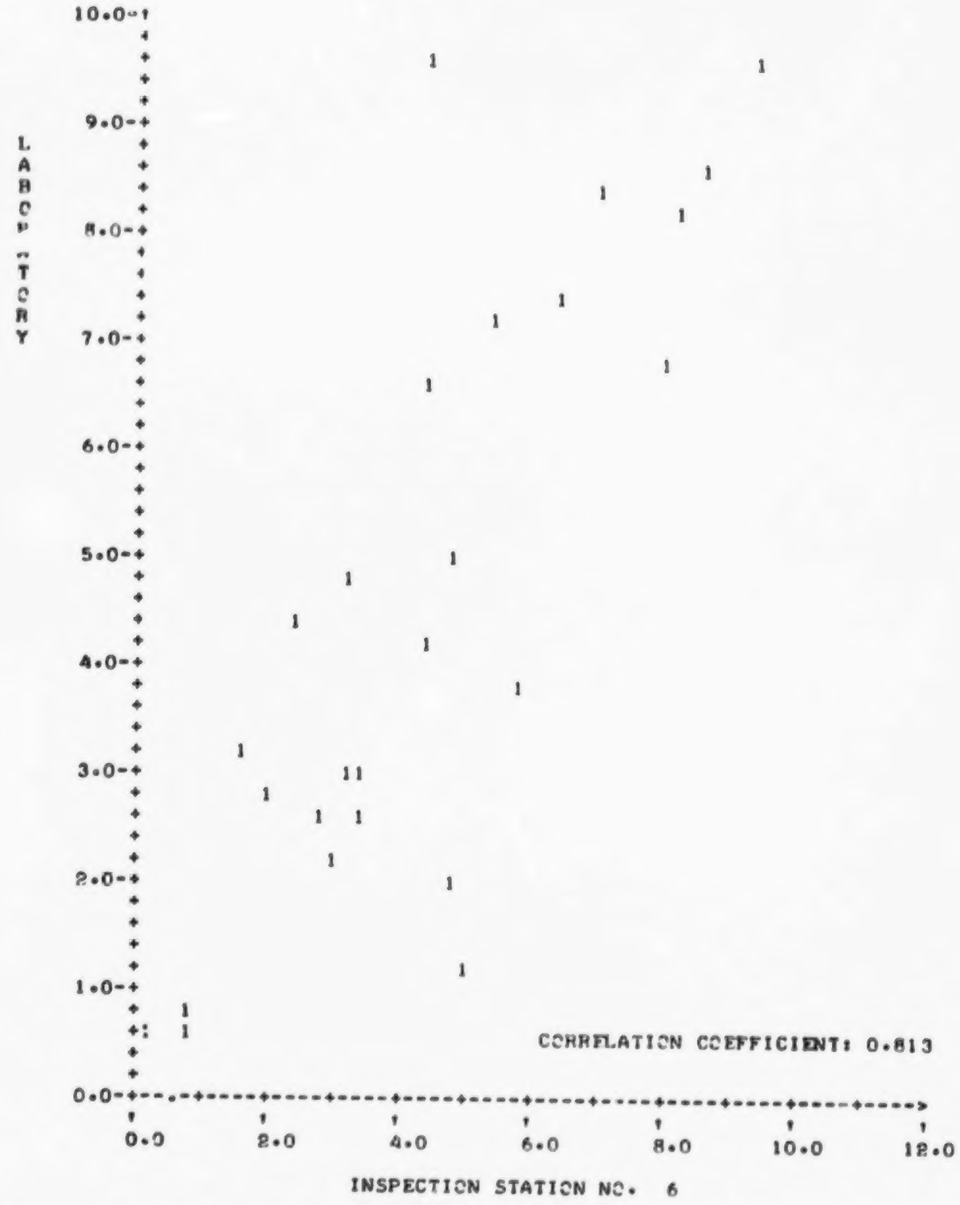

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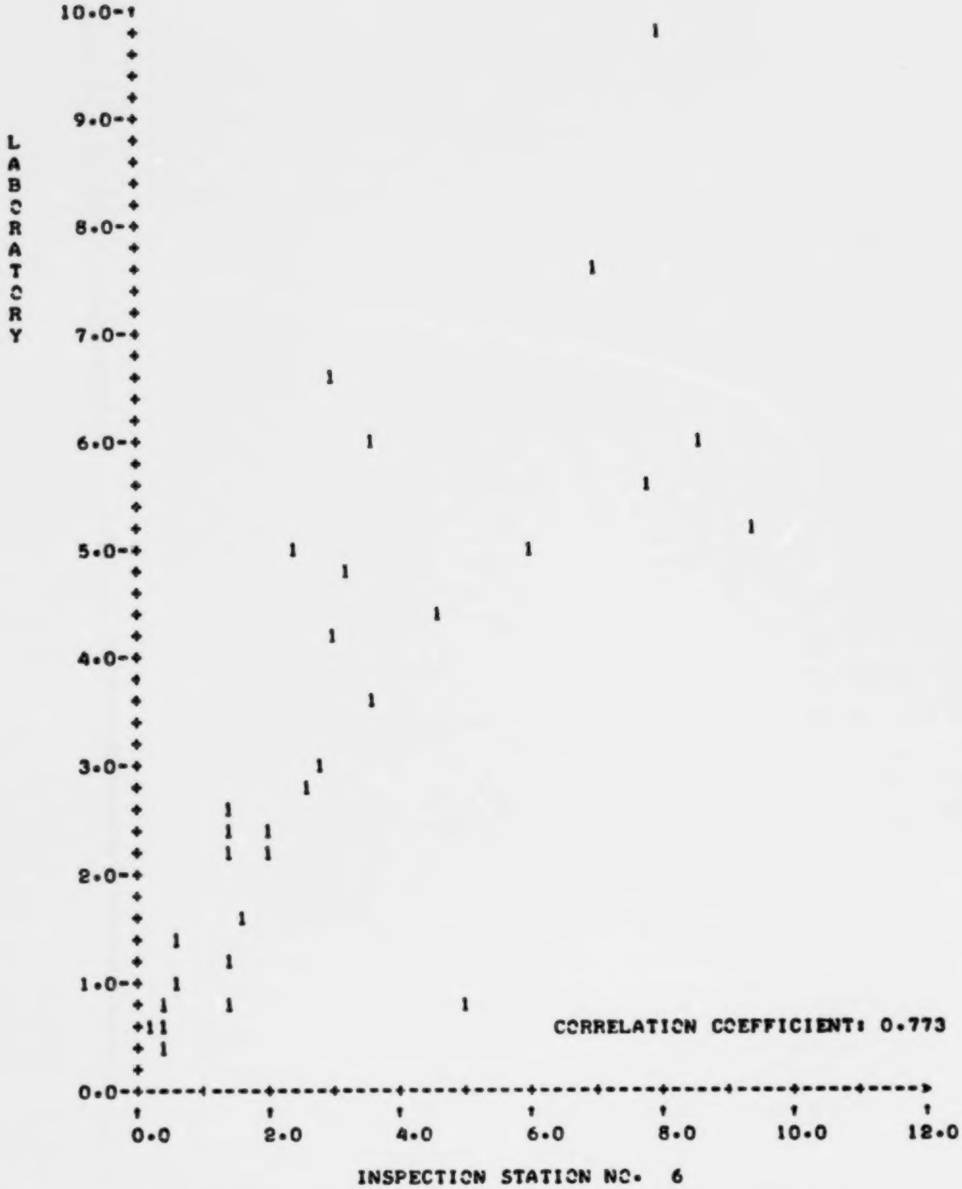

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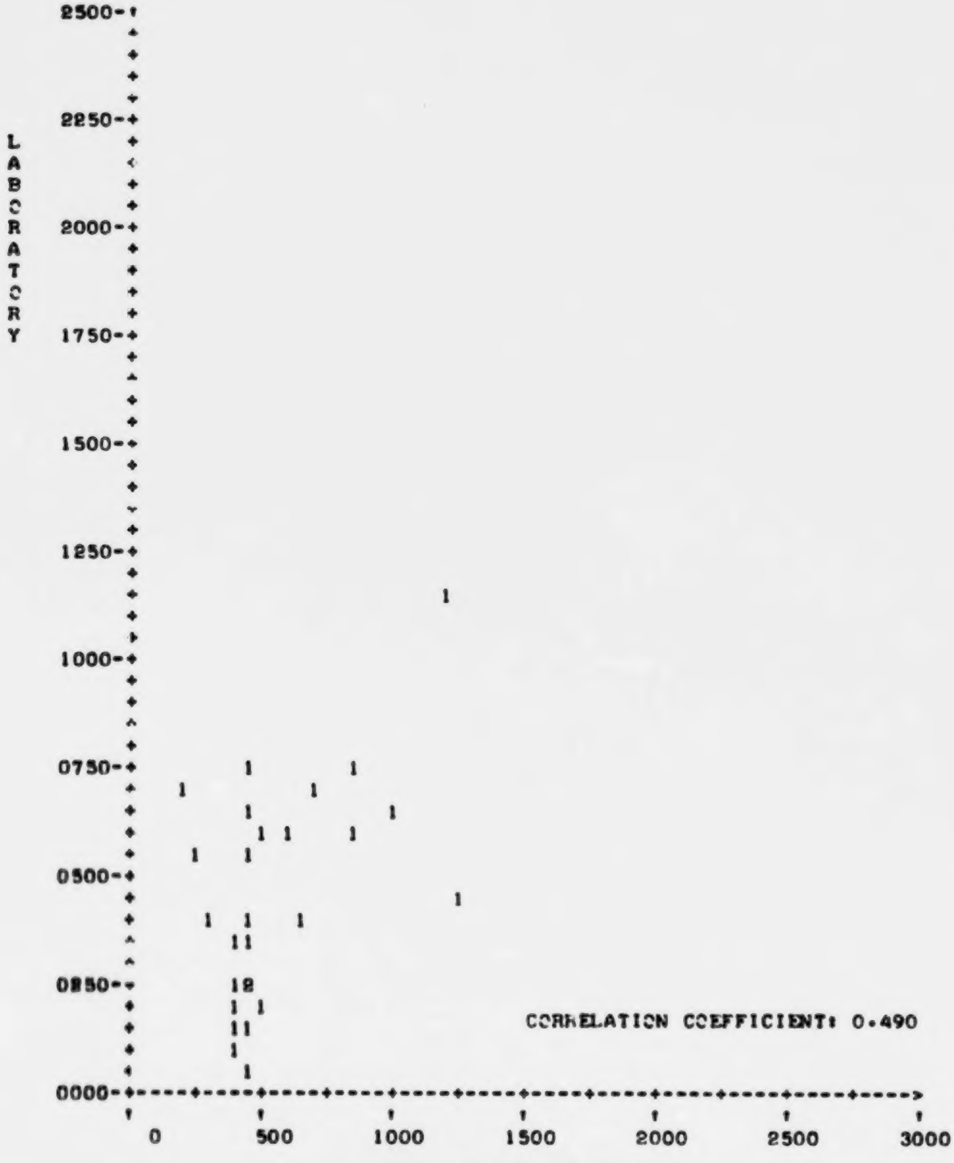

CORRELATION COEFFICIENT: 0.490

LEGEND: DIGITS SHOWN ON GRAPH REPRESENT THE NUMBER OF COINCIDENT DATA POINTS. IF MORE THAN NINE ARE COINCIDENT, AN 'X' IS PRINTED.

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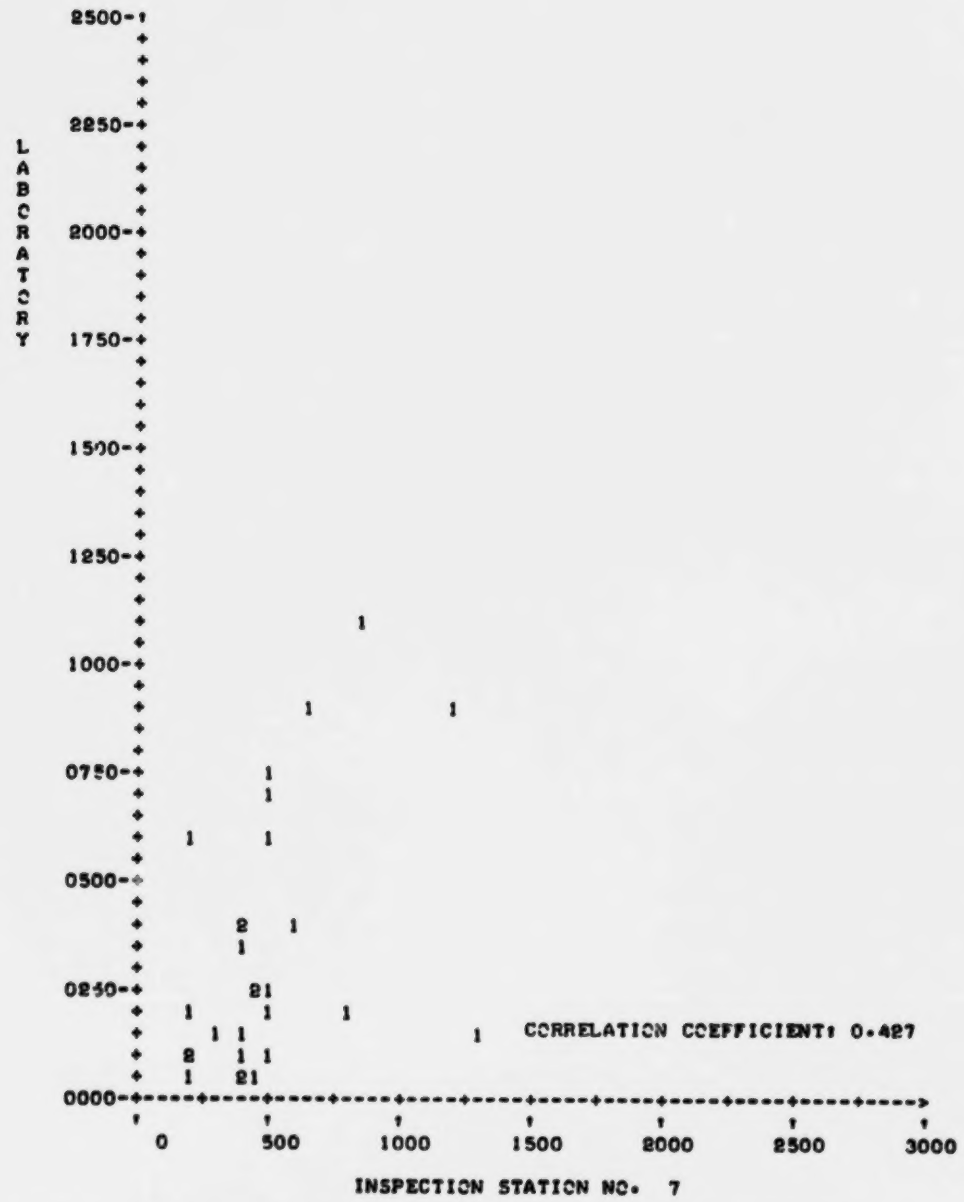
HYDROCARBONS AT 2500 RPM



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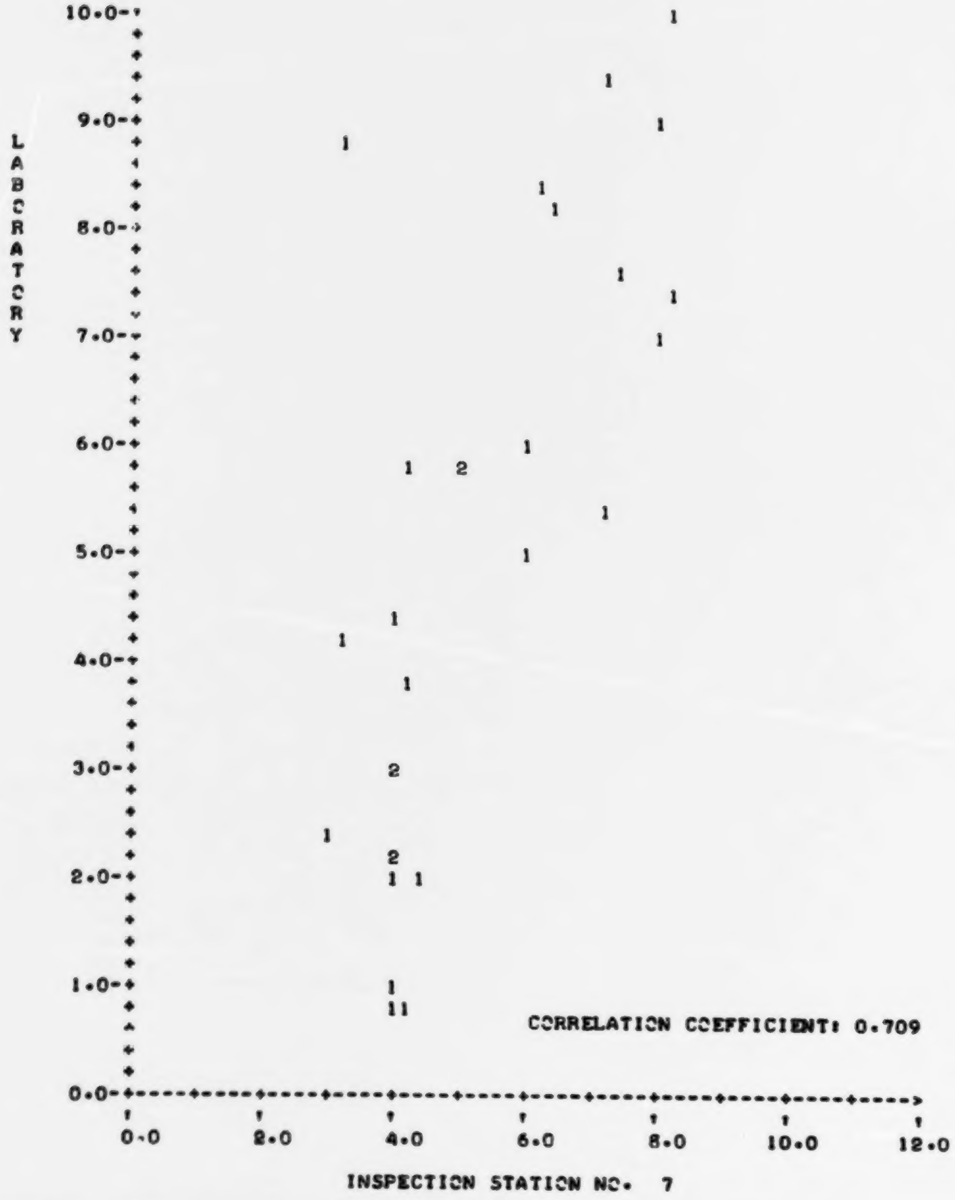

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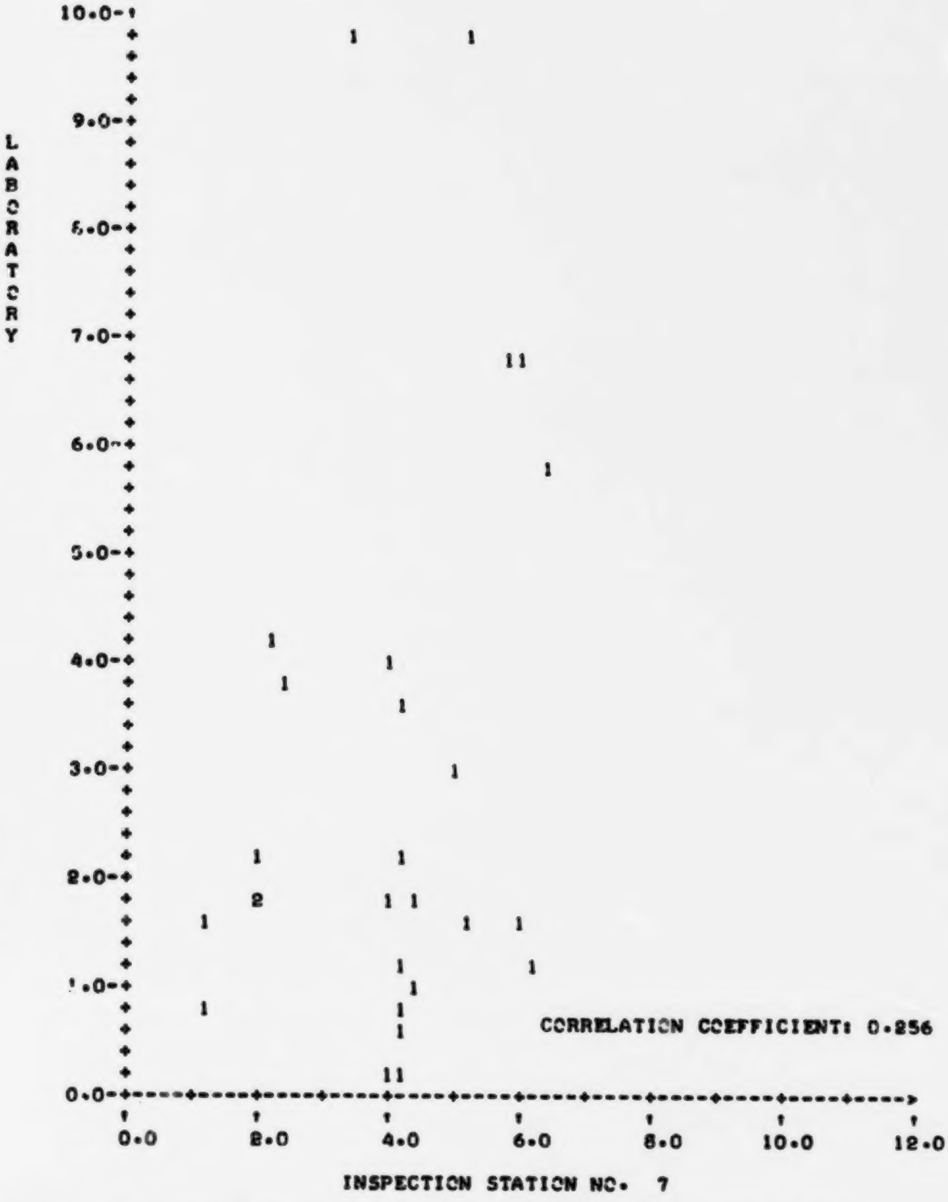
CARBON MONOXIDE AT 2500 RPM



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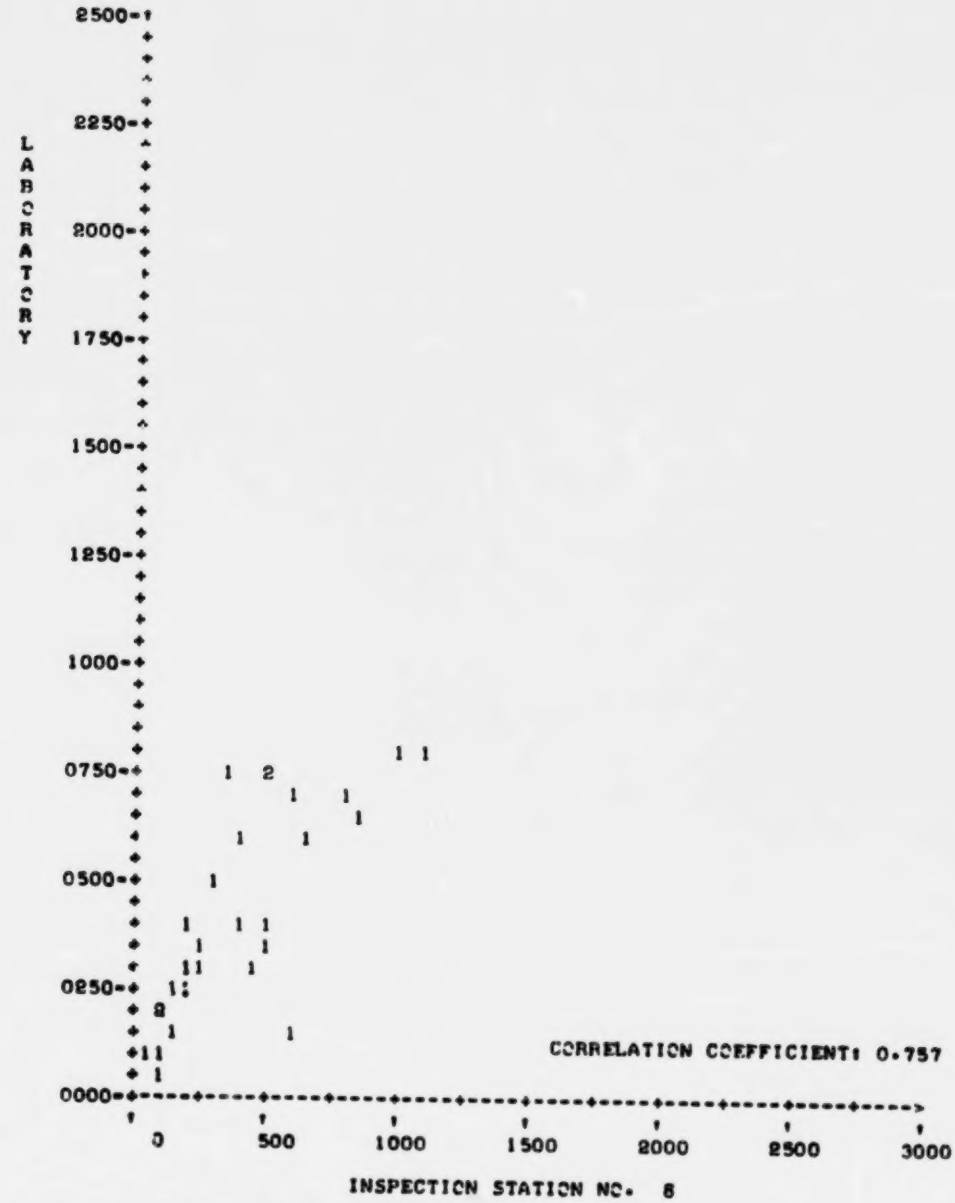
HYDROCARBONS AT IDLE



CORRELATION COEFFICIENT: 0.757

LEGEND: DIGITS SHOWN ON GRAPH REPRESENT THE NUMBER OF COINCIDENT DATA POINTS. IF MORE THAN NINE ARE COINCIDENT, AN 'X' IS PRINTED.

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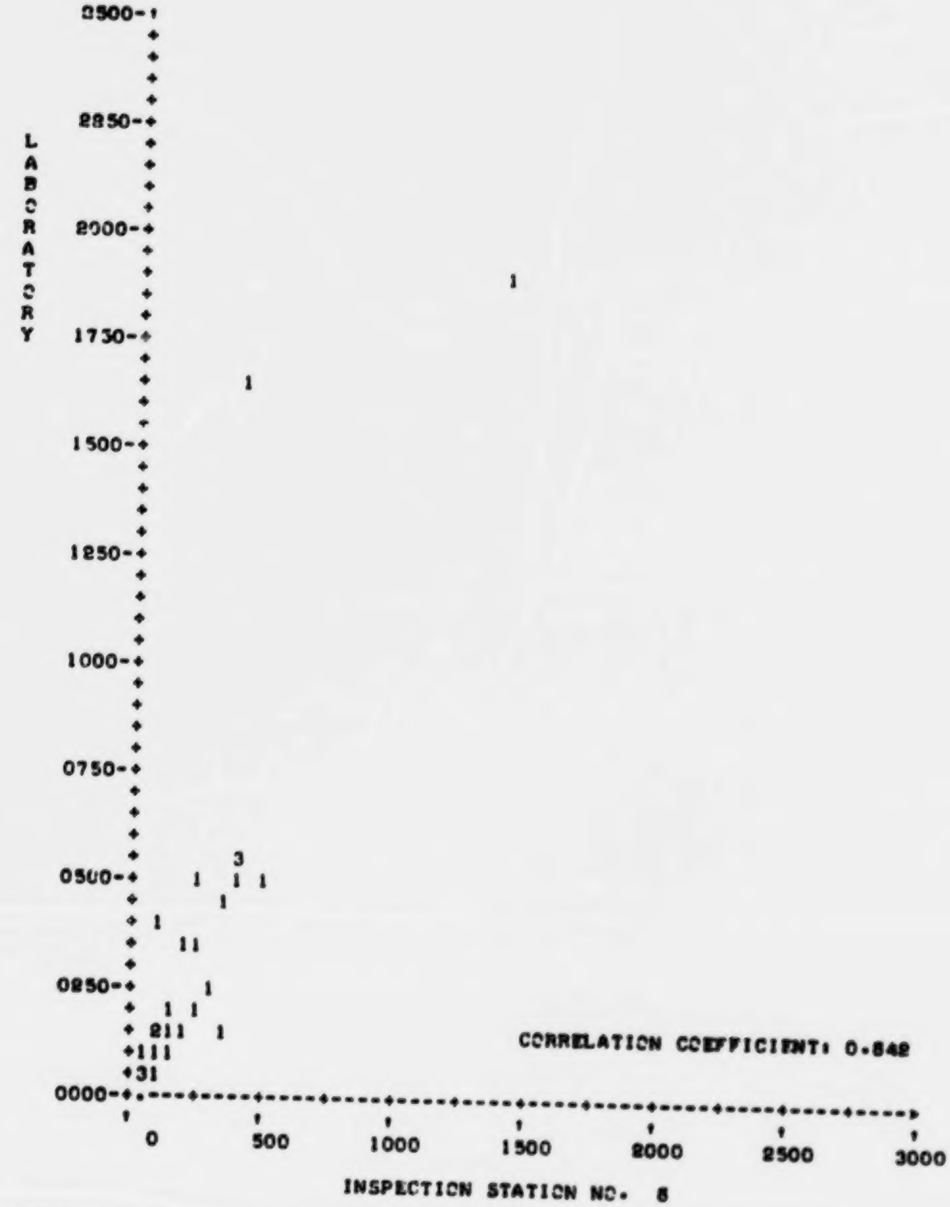
HYDROCARBONS AT 2500 RPM



CORRELATION COEFFICIENT: 0.842

LEGEND: DIGITS SHOWN ON GRAPH REPRESENT THE NUMBER OF COINCIDENT DATA POINTS. IF MORE THAN NINE ARE COINCIDENT, AN 'X' IS PRINTED.

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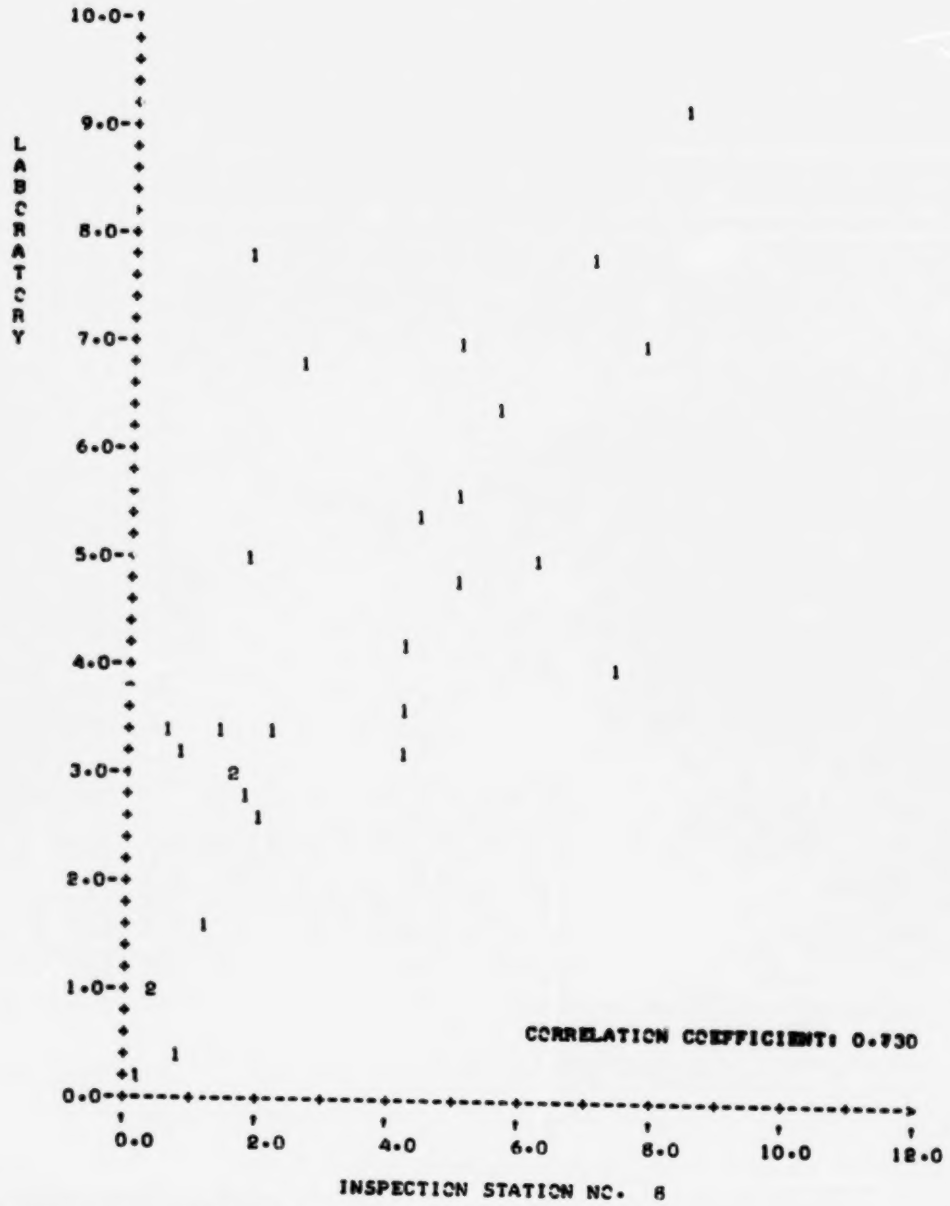
CARBON MONOXIDE AT IDLE



CORRELATION COEFFICIENT: 0.730

LEGEND: DIGITS SHOWN ON GRAPH REPRESENT THE NUMBER OF COINCIDENT DATA POINTS. IF MORE THAN NINE ARE COINCIDENT, AN 'X' IS PRINTED.

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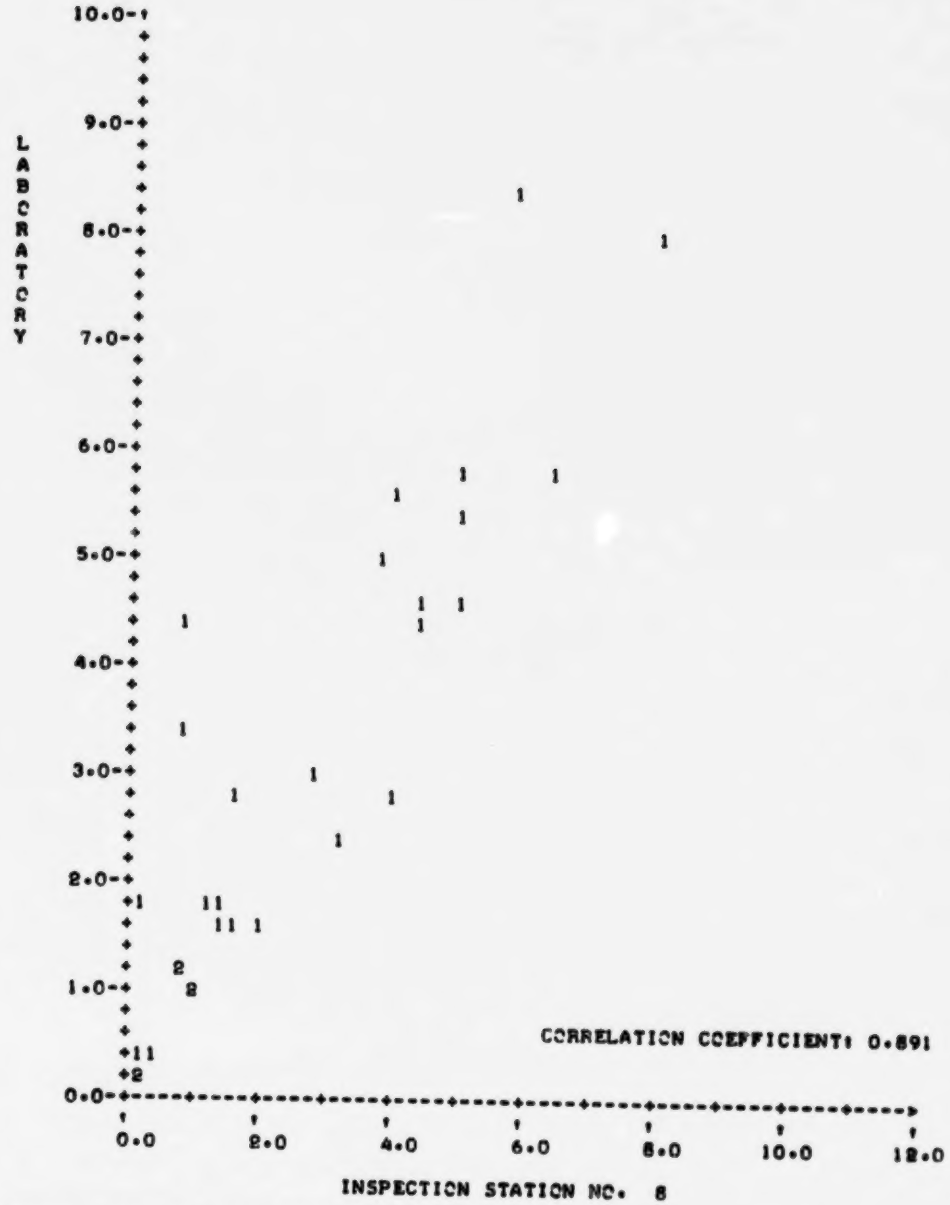
CARBON MONOXIDE AT 2500 RPM



CORRELATION COEFFICIENT: 0.891

LEGEND: DIGITS SHOWN ON GRAPH REPRESENT THE NUMBER OF COINCIDENT DATA POINTS. IF MORE THAN NINE ARE COINCIDENT, AN 'X' IS PRINTED.

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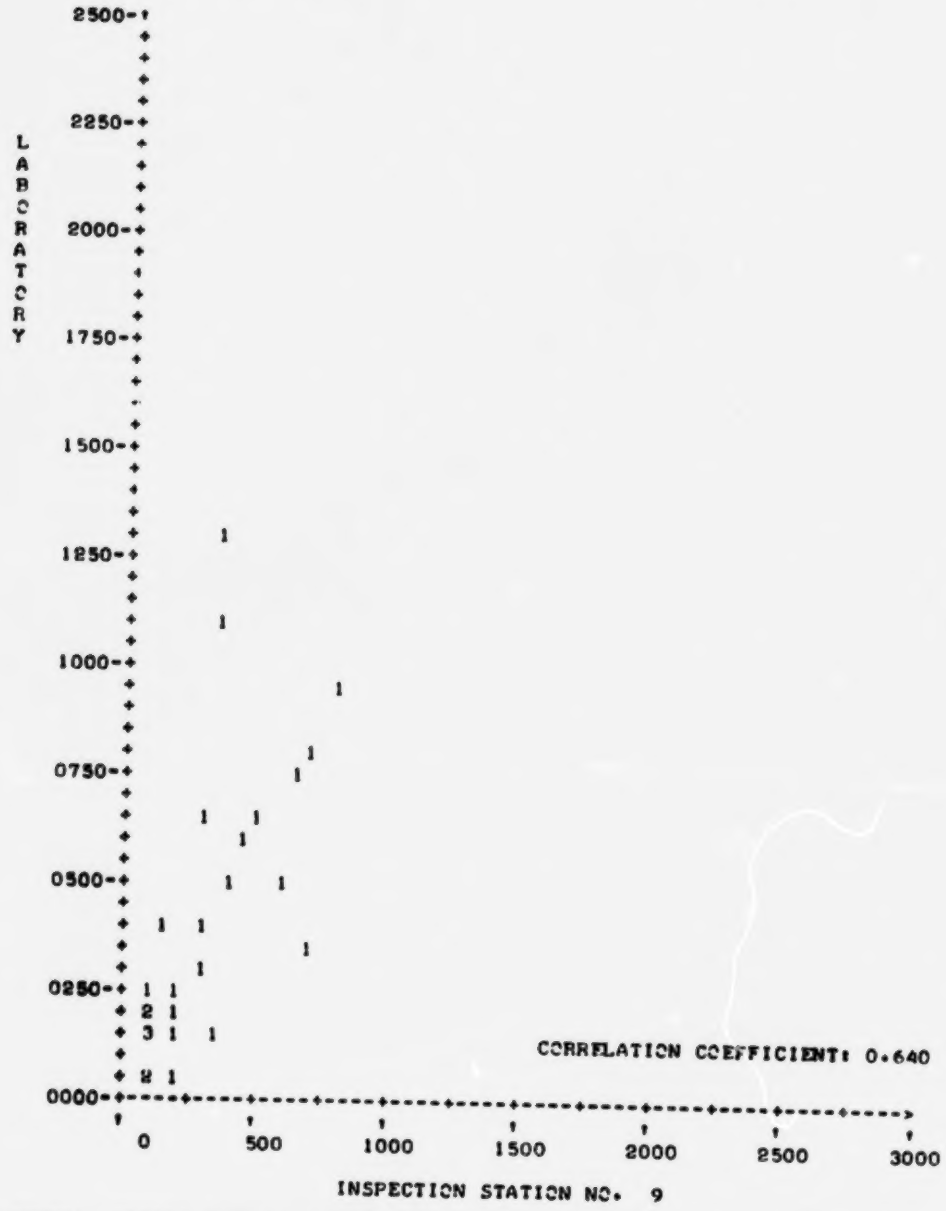
HYDROCARBONS AT IDLE



CORRELATION COEFFICIENT: 0.640

LEGEND: DIGITS SHOWN ON GRAPH REPRESENT THE NUMBER OF COINCIDENT DATA POINTS. IF MORE THAN NINE ARE COINCIDENT, AN 'X' IS PRINTED.

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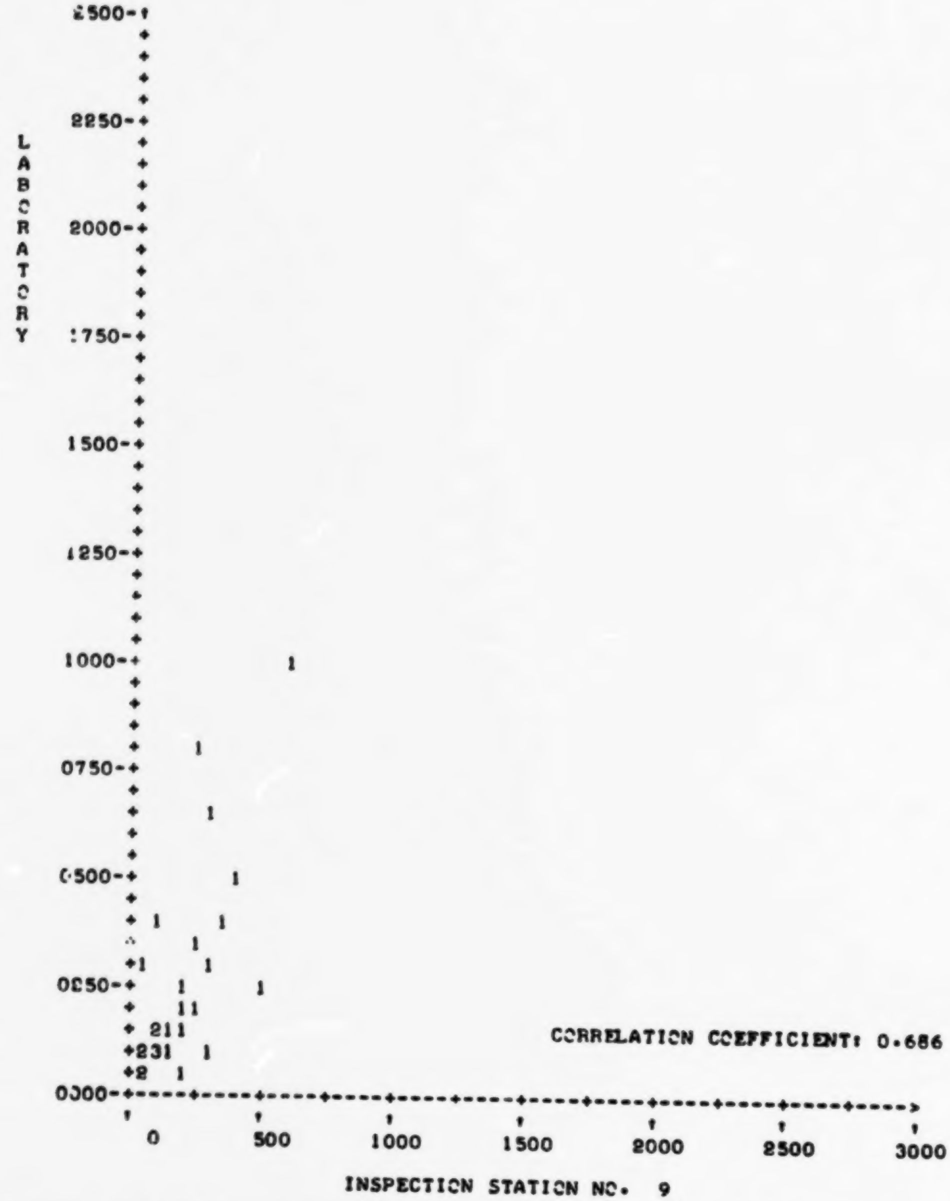

LEGEND: DIGITS SHOWN ON GRAPH REPRESENT THE NUMBER OF COINCIDENT DATA POINTS. IF MORE THAN NINE ARE COINCIDENT, AN 'X' IS PRINTED.

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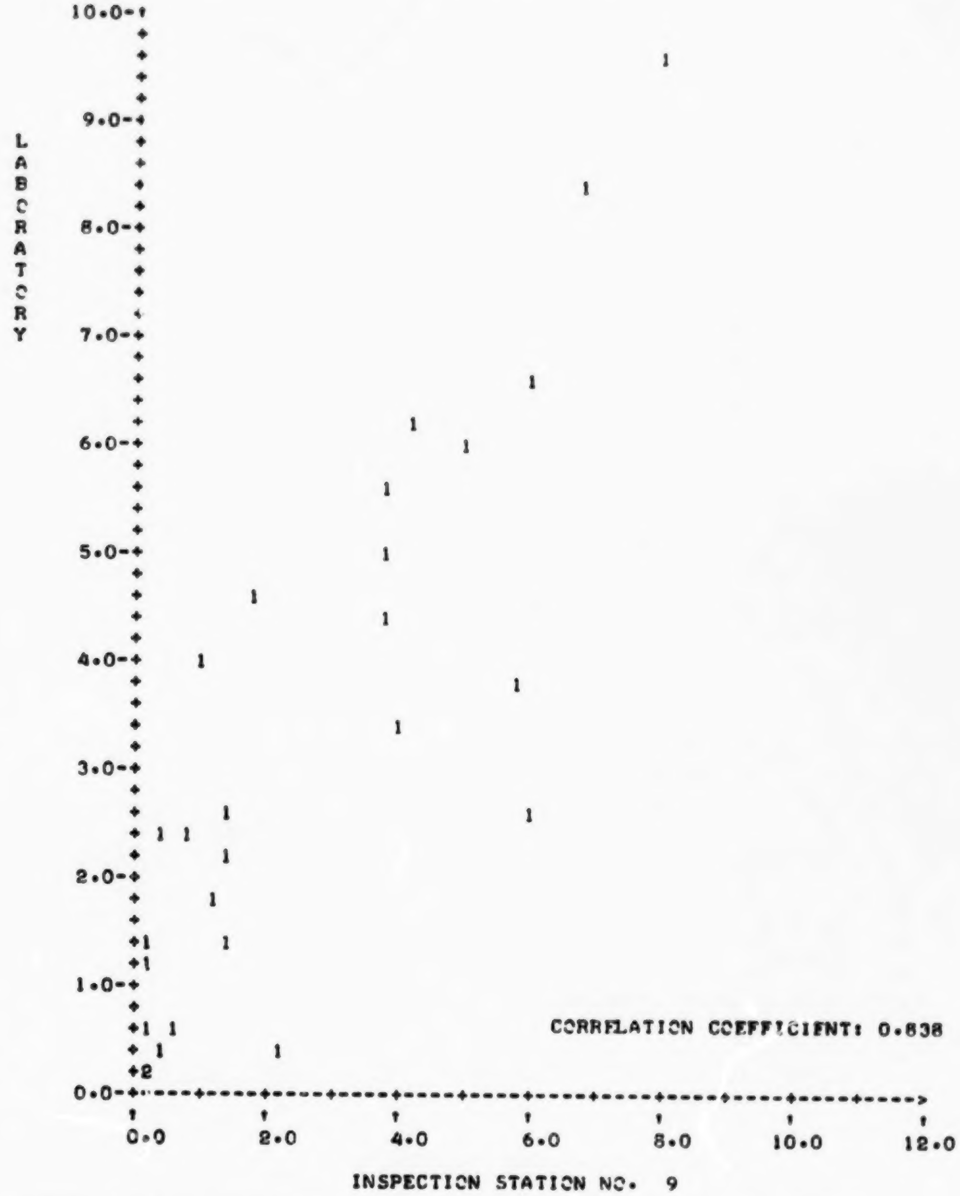

CORRELATION COEFFICIENT: 0.838

LEGEND: DIGITS SHOWN ON GRAPH REPRESENT THE NUMBER OF COINCIDENT DATA POINTS. IF MORE THAN NINE ARE COINCIDENT, AN 'X' IS PRINTED.

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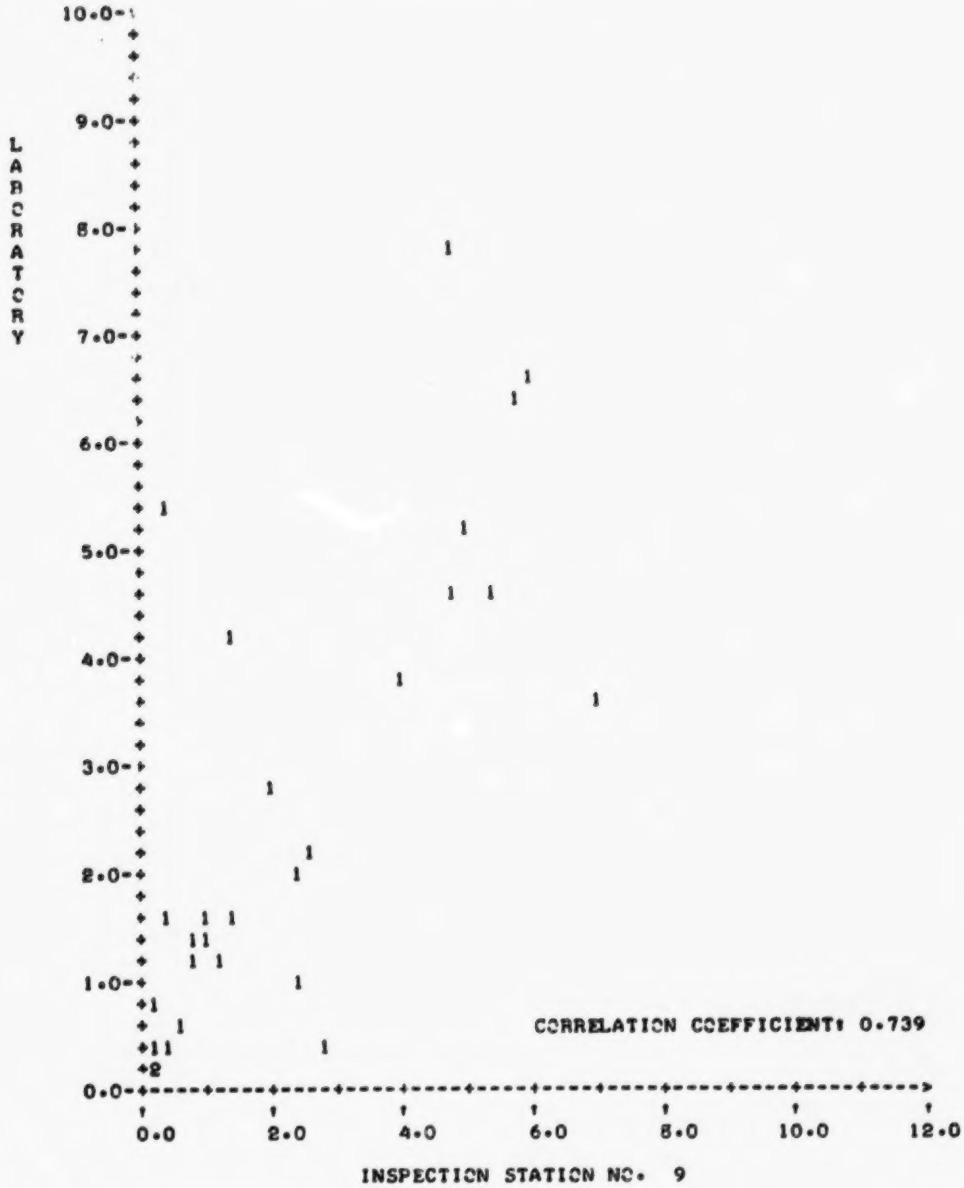
CARBON MONOXIDE AT 2500 RPM



LEGEND: DIGITS SHOWN ON GRAPH REPRESENT THE NUMBER OF COINCIDENT DATA POINTS. IF MORE THAN NINE ARE COINCIDENT, AN 'X' IS PRINTED.

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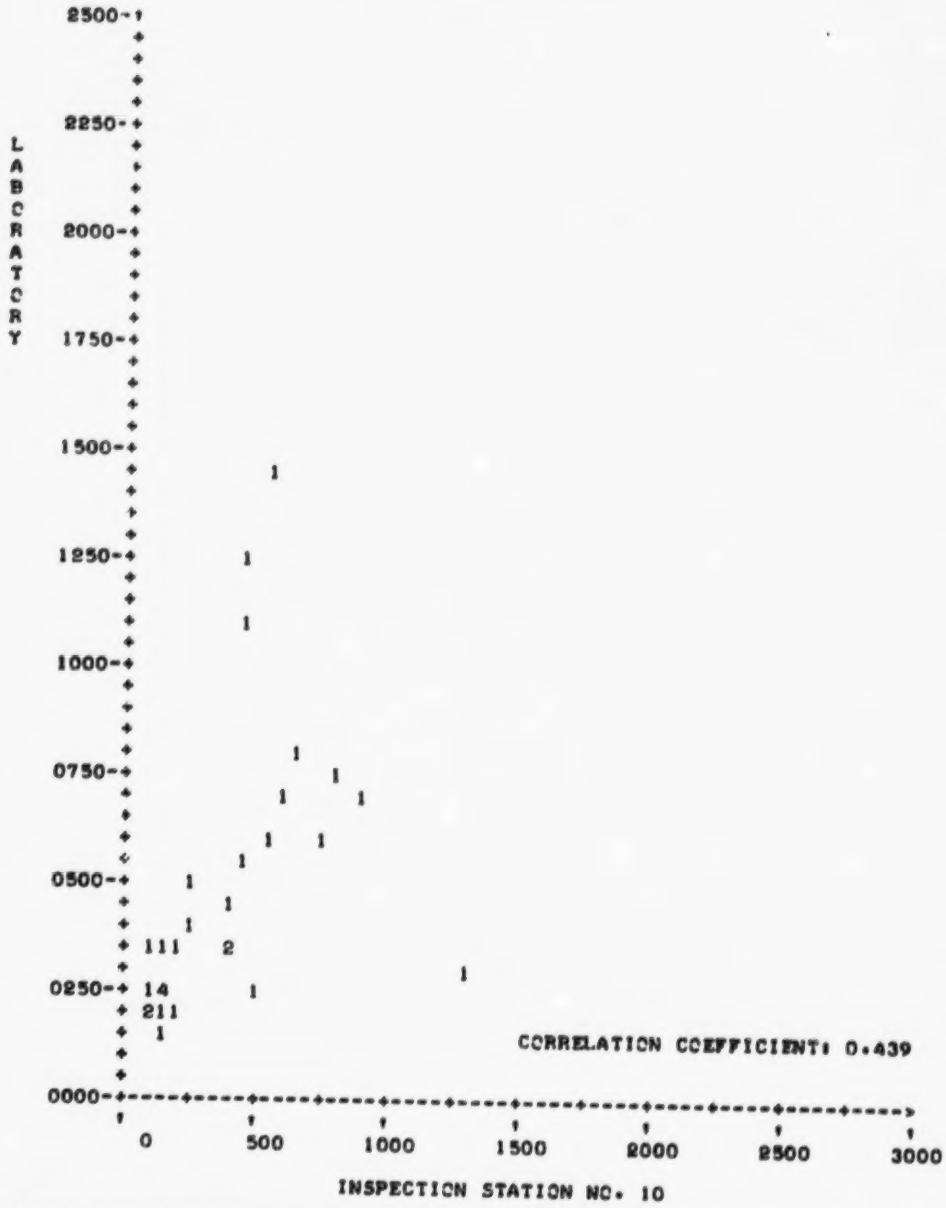

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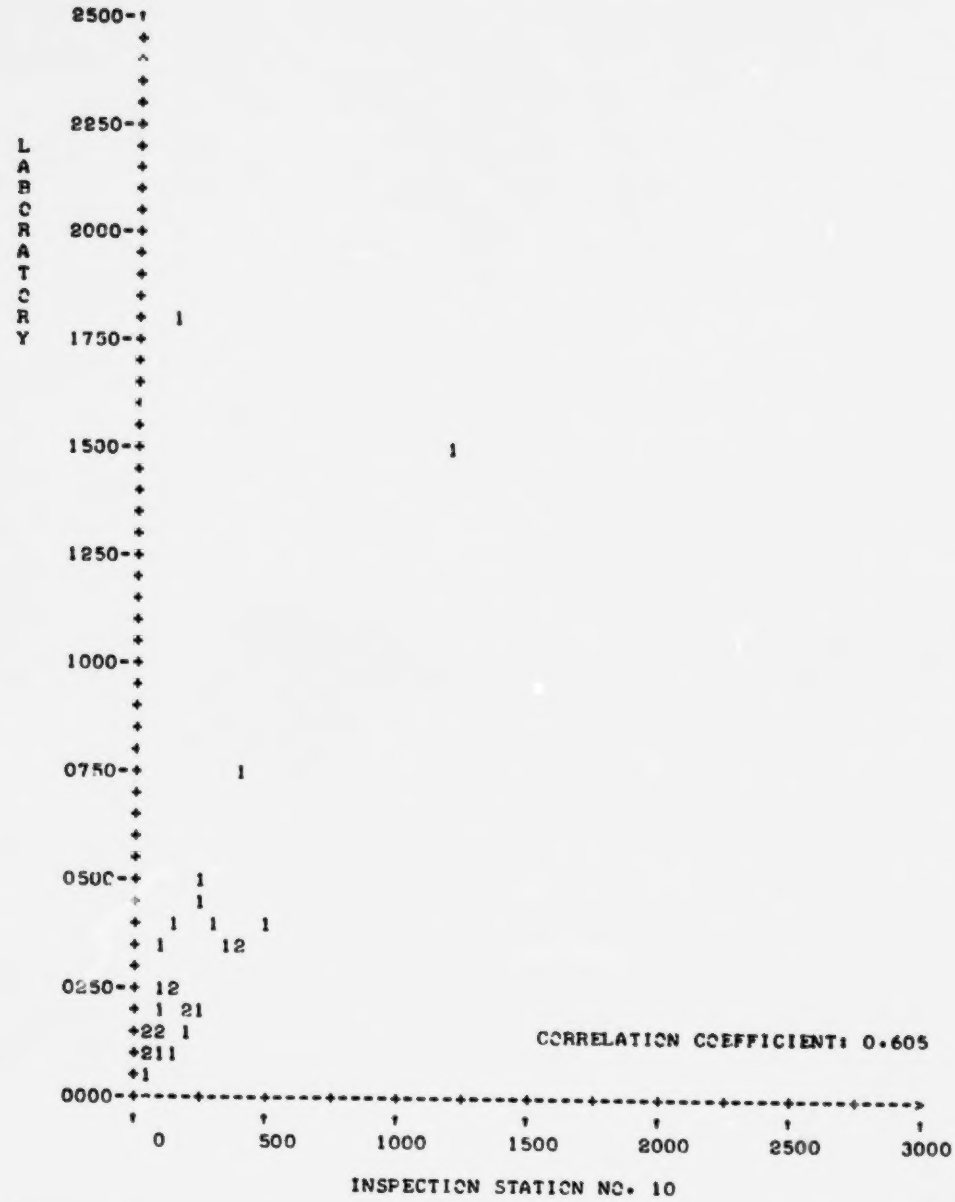

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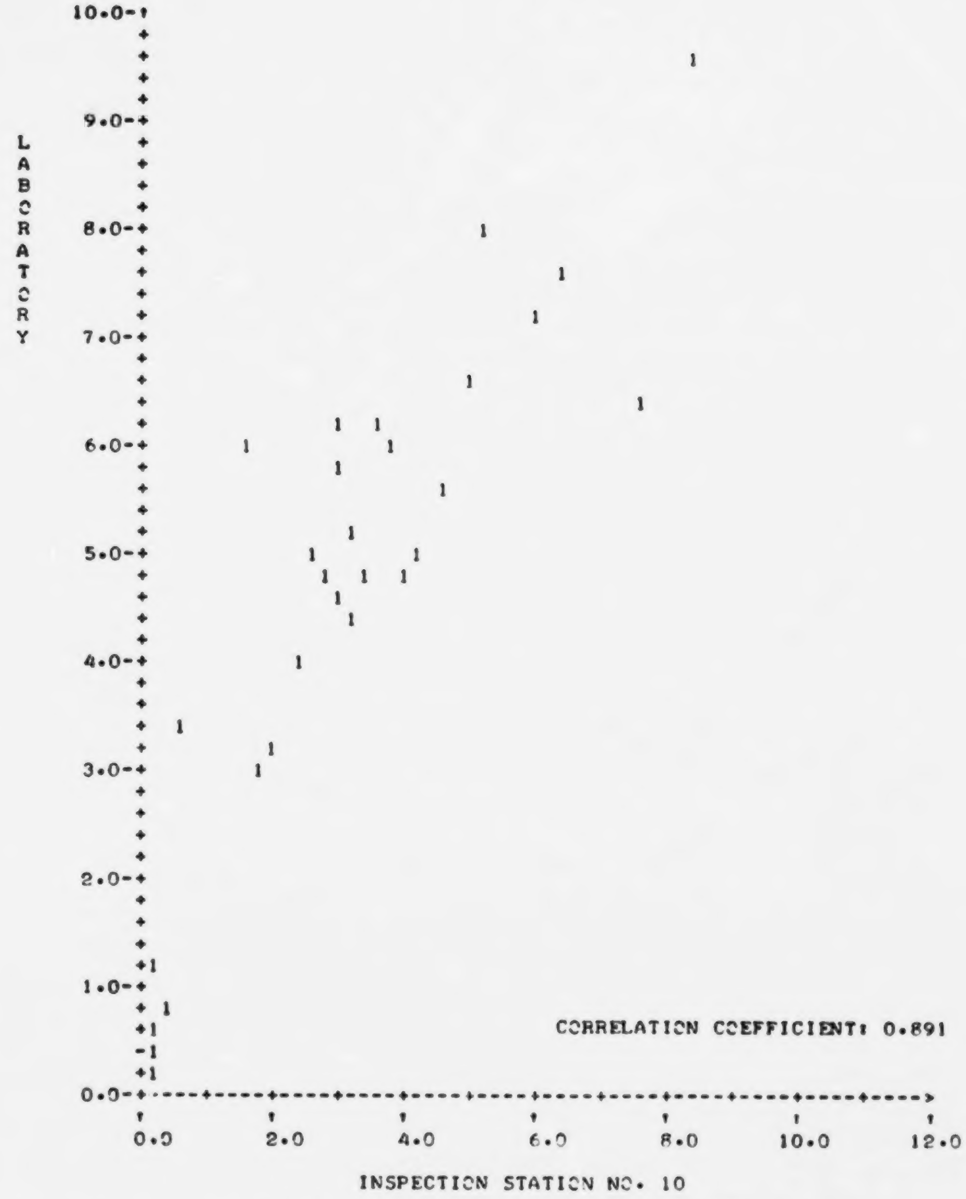

CORRELATION COEFFICIENT: 0.891

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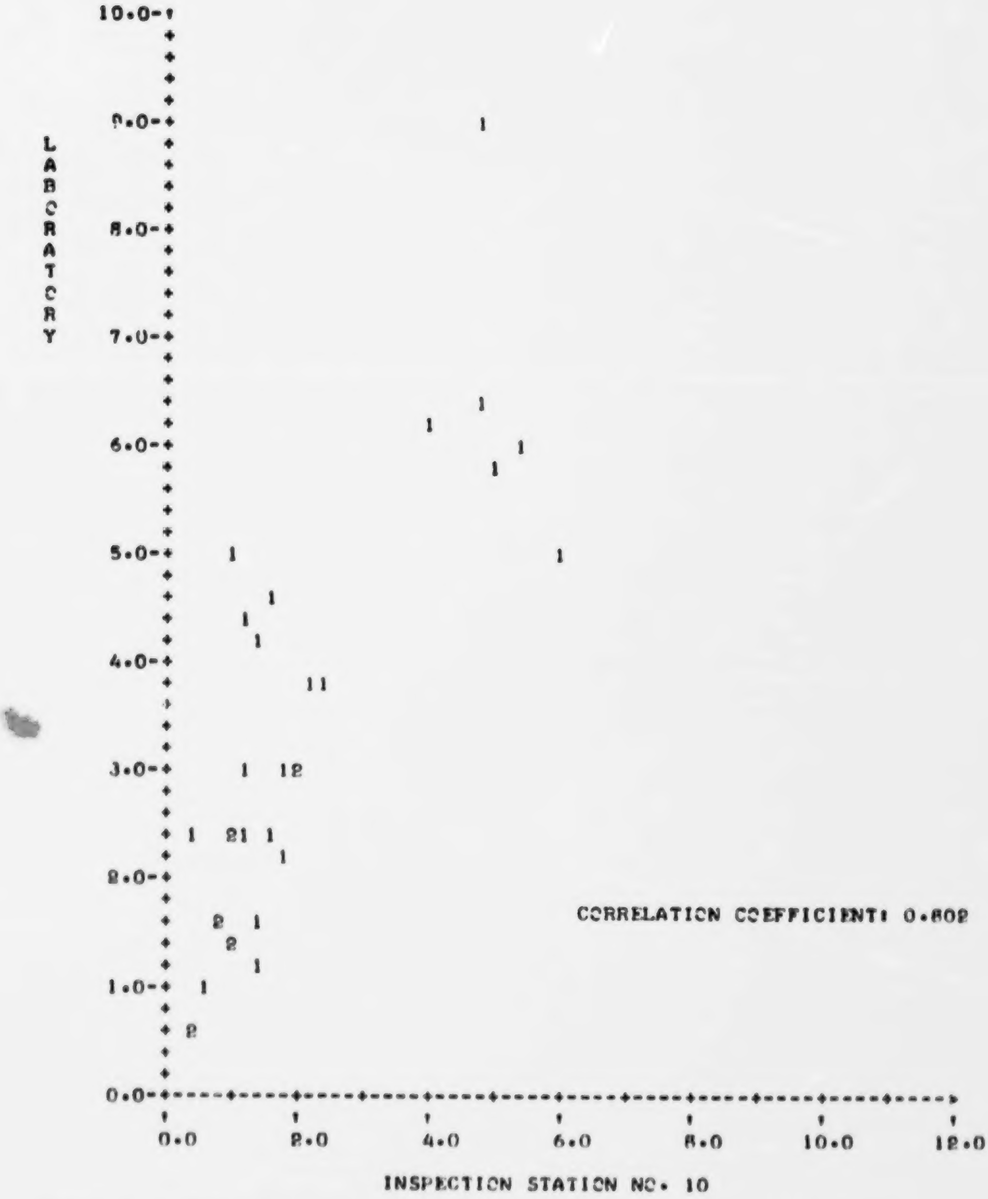

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